Health Assessment for

BAIRD AND MCGUIRE

HOLBROOK, NORFOLK COUNTY, MASSACHUSETTS

CERCLIS NO. MAD091041987

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104 (i) (7) (A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "...the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risks assessments, risk evaluations and studies available from the Administrator of EPA."

In accordance with the CERCLA section cited, this Health Assessment has been conducted using available data. Additional Health Assessments may be conducted for this site as more information becomes available.

The conclusions and recommendations presented in this Health Assessment are the result of site specific analyses and are not to be cited or quoted for other evaluations or Health Assessments.

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PUBLIC HEALTH ASSESSMENT

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Prepared by:

Massachusetts Department of Public Health

Under Cooperative Agreement with the

Agency for Toxic Substances and Disease Registry

Table of Contents

Contents Page Number

Summary

The Baird and McGuire site is located near the Cochato River in Holbrook, Massachusetts and about 400 feet east of the town of Randolph, Massachusetts. A total of 102 chemicals has been detected at the site. Surface and subsurface soils and ground water at the site are contaminated with insecticide [especially chlordane, dieldrin, endrin, 4,4'-dichlorodiphenyltrichloroethane (DDT) and breakdown products, and benzene hexachlorides (BHC's)], herbicides [2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)], volatile organic compounds, arsenic, and the constituents of creosote, e.g., methylated phenols (especially 2,4-dimethylphenol) and polycyclic aromatic hydrocarbons (especially naphthalene and 2-methylnaphthalene). Also detected in the surface soils at the site and neighboring wetlands was 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), a common contaminant of 2,4,5-T. Cochato River sediments contain elevated levels of the insecticide, polycyclic aromatic hydrocarbons, and arsenic. Fish obtained from the river and associated waterways contained DDT and its breakdown products, chlordane, polycyclic aromatic hydrocarbons, and, to a lesser extent, 2,3,7,8-TCDD.

Populations with the greatest potential for historical exposure to contaminants originating from the site are the company's workers, children who played at the site, nearby residents who received drinking water from the South Street municipal wellfield located adjacent to the site, and recreational fishermen and their families. Past exposure pathways of particular concern are: (1) occupational exposures to the workers (mostly inhalation and dermal exposure to the contaminants); (2) dermal, ingestion, and inhalation exposures to the children who played at the site; (3) ingestion of contaminated municipal well water; and (4) ingestion of contaminated fish. Although past exposures most likely did occur, the chemicals and dosages are difficult to determine due to the lack of monitoring data prior to the interim remedial activities. Due to the reported uncontained hazardous waste situation at the time, exposures could have been significant. Because of a lack of information on the distribution system, the residents who received the contaminated municipal drinking water and an estimate of what proportion they received are not known completely.

Community health concerns have been expressed with regards to the children who played at the site and the residents who ingested contaminated drinking water. Health impacts alleged by the community members as being associated with exposure to the site's contaminants follow: (1) various types of cancer and other chronic diseases (Hodgkin's disease, leukemia, melanoma, brain tumor, adrenal cancer, sarcoidosis, chronic endocrine problems, and weakened immune systems) experienced by young adults who played at the site as children; and (2) a perceived increase in cancer incidence and reproductive problems in nearby residents. Community concern is illustrated further by the existence of 35

individual lawsuits filed by families against the Baird & McGuire Chemical Company, Inc. and its insurance companies because of health problems allegedly stemming from exposure to Baird and McGuire contaminants.

From a review of the available medical and scientific literature and based on the contaminants present and the probable exposure routes, the potential health impacts stemming from past exposures could include chloracne, aplastic anemia or specific cytopenias resulting in immunosuppression and associated diseases, hemolytic anemia, neurological problems including convulsions, reproductive and developmental problems, and cancer especially non-Hodgkin's lymphoma, soft tissue sarcomas, liver cancer, lung cancer, leukemia and skin cancer. The health impacts mentioned have not necessarily occurred, but indicate what outcomes might have occurred. The actual doses of exposure are unknown, but the populations most apt to be impacted are the workers, the children who played nearby, and the residents who consumed contaminated municipal water. Particularly sensitive populations are: (1) the developing fetus, neonate, and young children because of immature nervous systems that could be sensitive to the neurological effects of some of the contaminants (especially the insecticide); and (2) individuals with an erythrocyte enzyme deficiency, such as pyruvate kinase and glucose-6-phosphate dehydrogenase (G-6-PD) deficiencies (certain ethnic groups contain a larger proportion of individuals with G-6-PD deficiency, i.e., Blacks, Greeks, Mediterranean Jews, and Filipinos) who could be susceptible to hemolytic anemia from exposure to naphthalene.

A 1985 adverse birth outcome study was conducted by the Massachusetts Department of Public Health (MDPH) utilizing existing health statistical data. This descriptive study included Randolph, Holbrook, and several nearby communities. Birth outcomes during the period 1980-84 were considered for congenital anomalies, fetal, neonatal and infant deaths, and low birth weight. Rates were compared to both Massachusetts and national standards. No statistically significant elevations were observed for any outcome for the towns of Holbrook and Randolph.

A descriptive epidemiologic study was conducted by the MDPH as part of this Public Health Assessment. Available cancer incidence data were examined for the two town area (1982-86). Standardized Incidence Ratios adjusted for age and sex were calculated for cancers of the stomach, liver, pancreas, lung, hematopoietic/ reticuloendothelial systems (i.e., leukemia and multiple myelomas), bladder, and kidney. Hodgkin's disease, non-Hodgkin's lymphoma, soft tissue sarcoma, adrenal cancer, malignant melanoma, and brain cancer were also considered in the analysis. The study encompassed the towns of Holbrook and Randolph, but concentrated on the two census tracts closest to the Baird and McGuire site (census tracts 4211 in Holbrook and

4203 in Randolph). Statistically significant elevations were observed in lung cancer incidence in Holbrook and Randolph, bladder cancer among males in census tract 4203, kidney cancer among males in census tracts 4203 and 4211, and non-Hodgkin's lymphoma among females in census tracts 4203, 4211 and, especially, both census tracts combined. Examination of occupation and smoking status information from the MDPH's Cancer Registry indicates that life style factors may have played a role in lung, kidney, and bladder cancer cases.

Significant elevations in non-Hodgkin's lymphoma incidence were not observed among either sex in the remaining one Holbrook and two Randolph census tracts. Examination of residential and occupational histories of the 22 non-Hodgkin's lymphoma cases in the two closest census tracts indicates that most cases were long-term residents (>10 years) and that 55% listed occupation as housewife. Although a causal relationship with the Baird and McGuire site cannot be determined from this study, concern arises because of several observations: (1) residents in these two census tracts, especially 4211 in Holbrook, are most likely to have received municipal water from the South Street wellfield; (2) several compounds suspected of being associated with non-Hodgkin's lymphoma occurrence have been detected in the subsurface soils at the Baird and McGuire site; and (3) low levels of these compounds have been detected in the South Street wellfield below the water table and located crossgradient from the site (under natural ground water flow conditions).

Current contaminant exposures are limited because of the interim remedial measures, the fencing of the site, site security, and the closure of the South Street wells; therefore, potential health impacts stemming from current exposures are less likely. Consumption of contaminated fish may result in an increased risk of cancer. Other potential adverse health effects from the consumption of contaminated fish could not be determined because of a lack of monitoring data and information pertaining to the use of the fishery.

Because of the current elevation in lung cancer incidence in Holbrook and Randolph, the emission of small-sized particulates (which may contain arsenic) during remediation is of concern if appropriate engineering controls are not implemented. Inhalation of particulate arsenic is known to have a multiplicative effect on the development of lung cancer in cigarette smokers. However, the potential for developing lung cancer should be reduced because engineering controls will be used. The potential for other health effects from remediation activities or following remediation will be assessed once additional information is available. However, particular care should be taken to minimize exposure of erythrocyte-enzyme-deficient individuals to naphthalene and, if present, arsine and methylarsines. The

Public Health Assessment will be modified by amendment, if warranted, when additional information is available.

Based on the available information, this site currently poses a public health hazard predominantly because of past exposures. Because of this determination, follow-up health activities for this site are being planned by ATSDR and MDPH.

Background

A. Site Description and History

1. Site Location and Current Physical Appearance

The Baird and McGuire National Priorities List (NPL) site is located at 775 South Street in Holbrook, Norfolk County, MA about 14 miles south of Boston at 42° 8′ 59′′ latitude north and 71° 1′ 39" longitude west (figure A-1). The site was placed on the U.S. Environmental Protection Agency (EPA) Proposed NPL in October of 1982. Currently, EPA defines the site as the approximately 34-acre area enclosed by a cyclone fence topped with barbed wire. The site extends north to Mear Road, west to South Street, south to the South Street Wellfield, and east to the wetlands on the other side of the Cochato River. The site is the location of the former Baird & McGuire Chemical Company, Inc. (BMCCI) which operated from 1912 to 1983. Originally the company was a chemical company; however, by 1949 the company was involved in mixing and batching operations. Within the site boundaries are (see figure A-2):

a. the former BMCCI facility area located on the slope of a hill in the western portion of the site. Currently, this area is covered with a synthetic cap in the location of the demolished tank farm, and laboratory and mixing buildings. The storage building contains the dioxin-containing demolition debris from the facility buildings, and is secured and alarmed against intrusion, smoke, fire, and heat. The office building has been sealed shut.

b. the area downslope and east of the facility area where a clay cap has been installed, and a ground water recirculation system is operating. This property is owned by the Fanny Marzynski Trust, and is the location of extensive past waste disposal activities by the BMCCI. The Fanny Marzynski Trust property (formerly owned by the New Can Company Inc.) within the site boundaries extends eastward to the wetlands on either side of the Cochato River. The Cochato River passes within 500 feet of the former facility area.

c. additional wetlands located south and north of the clay cap which are associated with the Cochato River, and another wetland located north of the former tank farm and separated from the northern wetlands by a raised railroad bed. An unnamed brook traverses the two northern wetlands and eventually empties into the Cochato River. The wetlands tend to be forested swamps

except for along the banks of the Cochato River where the wetlands are predominately grassy.

d. a seasonally wet area existing south of the facility area, west of the southern wetland, and north of the South Street Wellfield. This area is separated from the southern wetland by a dirt access road which leads to the wellfield. On occasion the access road has washed away such that the southern wetlands and the seasonally wet area have been connected.

Bordering the site are the following properties: (1) the South Street wellfield and Adolph Bauer Co. to the south, (2) residences on the other side of South Street to the west, (3) the Phillips Brothers Chemical Company/Holbrook Chemical Company to the north, and (4) the New Can Company Inc. facility located in the Cochato Industrial Park to the east.

2. Operational Activities

The BMCCI began as a chemical manufacturing company in 1912. By 1970, the facility processes consisted of mixing and batching such products as herbicides, insecticide, disinfectants, soaps, floor waxes, and wood preservatives. The products were mixed, packaged, and stored at this facility prior to distribution. Before ceasing operations in April of 1983, BMCCI used, purchased, and stored a wide variety of chemicals and products, including DDT, dieldrin, chlordane, lindane, benzene, kerosene, creosote, sodium arsenite, toluene, methanol, xylene, coal tar, phenols, methoxychlor, and wax polymers. Refer to Appendix B for a more comprehensive list of known chemicals and products.

According to records from the Massachusetts Department of Labor and Industries (DL&I), as early as 1949, the company was involved in the dilution of liquid concentrates of DDT, chlordane, pyrethrum, methoxychlor, and piperonyl butoxide [77]. The diluted products were packaged for wholesale distribution. According to a 1954 memorandum from the DL&I files, DDT was the principal insecticide handled, and was received in lump form, then mixed in deodorized kerosene by agitation and heat in large steam jacketed vats. The DDT solution was then transported by pipe to the packaging room. Another DL&I memorandum, dated 1967, indicated that about 30,000 gallons of 42% aqueous solution of sodium arsenite were prepared each year. Most of this preparation was used as a potato top and weed killer. Various other known processes are reported in the Phase I RI, and included: (1) the cutting of malathion to 57% with emulsifiers, (2) the blending of pyrethrum and diazinon with kerosene, and (3)

the emulsification of coconut oil fatty acids with potash or caustic soda.

The BMCCI plant included an office building, a tank farm, a laboratory building, a mixing vat building, a storage building, and a small concrete block building (figure A-3) [44,85]. The buildings were situated on the hillside in the western portion of the current site. The tank farm contained 33 above ground vessels with capacities to 12,000 gallons [31], which were used for chemical storage, and, perhaps, as reactors or mixing vats. Also located here were 8 underground storage tanks with capacities ranging to 5,000 gallons [31]. The laboratory building was used for packing products into containers and for labeling the containers, and, to a lesser extent, for mixing products and storage [85]. The mixing vat building contained a number of mixing vats (some with steam jackets for heating purposes) that were used to mix floor waxes, insecticide and disinfectants [85]. Chemical storage may have also occurred here in storage tanks [31]. The concrete block building was located between the laboratory and the mixing vat building, and contained a tank for the storage of waste water from the mixing vat building [85]. The storage building was used to store products prior to distribution.

What is known of the waste disposal practices by the BMCCI is given in detail in the Phase I RI, and, for additional information, refer to that document. Some of the known practices are summarized below.

The 1959-1961 reports by Northeast Consultants Inc. for the Town of Holbrook documented yellow-green discharges from the plant to the seasonally wet area near the South Street Wellfield via a drain line and surface runoff, and determined that this waste was the source of contamination of South Street Well #3. As a result of the Northeast Consultants' recommendations, the BMCCI rerouted the drain line to discharge into the unnamed brook north of the plant. Despite this action, the Phase I RI reports incidents of observed yellow-green liquid in the seasonally wet area to a depth of 3 to 4 feet. Within the Phase I RI, an estimation was presented that 200,000 gallons of yellow-green phenolic waste ran to this area.

The Phase I RI compiled a table of waste disposal and drainage systems at the facility. In summary, the waste disposal practices entailed: (1) the use of cesspools for waste from the mixing vat and laboratory buildings and from the court yard area; (2) subsurface tanks and sump for waste from surface runoff and the buildings (at times the tanks/sump overflowed); (3) subsurface pipes for runoff from the tank farm, yard area, and cesspools to the unnamed brook

and wetland; (4) catch basins which received runoff from the tank farm and delivered it to the sump or the unnamed brook; (5) the creosote aeration lagoon and creosote collection pit (both were unlined) which received waste from ground water inflow; (6) the creosote collection tank which received waste from the creosote collection pit and from interceptor wells; and (7) a former borrow pit, located in the undeveloped area between the facility and the Cochato River, which received waste from intentional disposal and surface runoff.

3. Site History and Remediation History

The Baird and McGuire site has a complex remediation history. The major points of the history are described below. After the completion of the South St. municipal wells in 1958, well #3 was shut down because of phenol contamination detected in water samples taken from the well [43,85]. As a result of studies by a consultant for the town, the BMCCI rerouted a drainline from the seasonally wet area near the wellfield to the unnamed brook. Well #2 was utilized intermittently for emergency purposes and remained open until 1980, when the DEQE detected organic contaminants during a survey of municipal water supply wells [23,43,85]. Well #1 remained open because repeated ground water monitoring of the well revealed contaminant concentrations below federal Maximum Contaminant Levels (MCLs) [23]. However, well #1 was shutdown permanently in February of 1982, as a result of DEQE site inspections that were prompted by the observed contamination of the Cochato River by the BMCCI. The site inspection revealed poor waste disposal practices.

As a result of DEQE site visit reports, the BMCCI implemented various remedial actions during the period February to April of 1982 (see figure A-3). These actions entailed: (1) the removal of a pipe that was discharging waste into the northern wetland; (2) the filling of a cesspool with concrete; (3) the installation of tanks, sumps, and a catch basin to receive effluent from the mixing vat and laboratory buildings and surface runoff; (4) the installation of booms on the Cochato River and the unnamed brook to retard creosote migration; (5) the installation of a creosote aeration lagoon and recovery pit; and (6) the fencing of the creosote aeration lagoon. Despite these voluntary remedial actions, another DEQE site inspection in June of 1982 resulted in the detection of a variety of on-site spills, and found evidence of suspicious waste discharges [23].

In October 1982, the Baird and McGuire site was added to the EPA's Proposed NPL. A Remedial Action Master Plan was

completed by NUS Corporation in March, 1983 on behalf of EPA [86]. The EPA became more actively involved in March of 1983 as a result of the breach of the creosote recovery system which resulted in creosote discharging into the Cochato River during a period of heavy rain. The breaching of this system caused the immediate closing of the sluice gate that regulates the diversion of river water to the Richardi Reservoir [23]. The EPA's initial response was the repair of a temporary waste lagoon, maintenance of the creosote collection system, and fencing of contaminated areas. In April of the same year, NUS Corporation conducted a Preliminary Site Assessment using the available site information [85]. The Preliminary Site Assessment indicated that the site posed an imminent threat to the Cochato River and to the Richardi Reservoir. As a result of Goldberg-Zoino & Associates, Inc.'s (GZA) hydrological assessment of the site and design studies on behalf of EPA, certain emergency remedial measures were implemented [46].

In order to decrease contaminant discharge into the Cochato River, the following emergency remedial measures were conducted by EPA in accordance to provisions in the National Oil and Hazardous Substance Contingency Plan: (1) the excavation and off-site removal of over 1,000 cubic yards of contaminated soils and hundreds of gallons of pesticides and liquid wastes found buried in the back of the facility [August to September, 1983]; (2) the installation of a clay cap in the excavated area (former borrow pit), and regrading the site [December, 1983 - May, 1984]; (3) the installation of a ground water recirculation system [early 1984]; and (4) the installation of a system to recover the floating creosote layer from the interceptor wells of the recirculation system. A six foot chain link fenced was installed around the clay cap area. In April 1984, DEQE assumed responsibility for the ground water recirculation system's operation and monitoring, and the general security of the site. The clay cap and ground water recirculation system are interim measures until permanent site cleanup can be conducted.

The Phase I of the Remedial Investigation/Feasibility Study (RI/FS) was initiated in 1983 and completed in May, 1985 [43]. The study area for the Phase I RI encompasses about 60 acres [44], and includes the BMCCI property, the South Street Wellfield, an undeveloped land parcel, the Fanny Marzynski Trust property, and the Holbrook Chemical Company property. The Phase II RI was conducted during the period from 1985 to 1986 to address various on-site and off-site contaminant concerns [42]. The Cochato River/Baird and McGuire Site Sediment Focused Feasibility Study (FFS) [23] was conducted from December 1987 until June 1988 by Ebasco

Services Inc. in order to investigate the contamination of the Cochato River and to supplement the previous two RI's.

When dioxins were discovered in soils in 1985 as a result of Phase II RI monitoring, the EPA's removal program was reactivated. An Initial Remedial Measure (IRM) conducted from July of 1985 to 1987 included the following actions:

a. the demolition of the dioxin-containing on-site buildings (i.e., the laboratory, concrete block, and mixing vat buildings) and the tank farm, and storage of the demolition debris in the alarmed and secured storage building [32];

b. the boarding up of the former office building;

c. the installation of a temporary synthetic cap over the area where the tank farm and buildings were located; and

d. the installation of 5,700 feet [32] of a chain-link security fence which is topped with barbed wire, resulting in the enlargement of the site area to 34 acres. The fence crosses the Cochato River to include the wetlands along the eastern bank of the river.

In addition, the relocation of an active municipal water main that distributed water to the South St./Brookville section of Holbrook was authorized as a result of Phase I RI activities. Because it crossed a highly contaminated area of the site, the water main was relocated to South Street in 1987 [32].

Following the completion of the Phase I and II RIs, a Record of Decision (ROD) was signed in 1986 for the site. At that time, EPA divided site remediation into Operable Units (OU) [31]. OU #1 entails the extraction and treatment of ground water. Construction of the treatment system has recently begun. OU #2 calls for excavation and on-site incineration of contaminated soil. The debris from the buildings' demolition are to undergo incineration also. The bid solicitation package is nearing completion. OU #3 addresses sediment contamination of the Cochato River. A second ROD was signed in 1989 for this third OU, and entails the excavation of Cochato River sediment from the site to just north of Union Street, and on-site incineration of the sediment. OU #4 addresses the replacement of the Lost Demand due to the closing of the South Street Wellfield because of Baird & McGuire site-related contamination [32]. The Lost Demand is defined as the daily rate of water extracted from the South Street Wells by the town of Holbrook for use within the town. The ROD was signed in

September 1990 and entails the reactivation of the Donna Road wellfield.

B. Site Visit

On July 11, 1989, a Site Visit was conducted at the Baird and McGuire site by the ATSDR Region I Representative, a Senior Environmental Analyst from MDPH, and the EPA Regional Project Manager. During the course of the Site Visit, the current site status (interim remediation activities and evidence of transport mechanisms) and appearance (physical hazards and security) were observed. Interim remediation techniques that were inspected consisted of:

1. the integrity of the clay cap and synthetic cap - both caps appear to be intact and in good shape;

2. the ground water recirculation system consisting of two withdrawal wells and several reinjection points;

3. the locked and alarmed storage building which is housing the dioxin-containing demolition debris; and

4. the silt barrier located in order to impede runoff from the facility area to the unnamed brook, especially during times of soil movement activities.

Other observations included the presence of seeps, the grass lawn covering the clay cap, the location of the South Street wellfield, the location of nearby residences, the grading of the site and nearby wetlands, and the overall well-maintained state of the site. The physical hazards and site security observations are presented in the "Environmental Contamination and Physical Hazards" section.

C. Demographics, Land Use, and Natural Resource Use

This section provides a description of the population, land use, and natural resources in the region containing the Baird and McGuire site and does not indicate that human exposure has or will occur. Past, current and future exposure scenarios will be presented in the section entitled "Human Exposure Pathways."

1. Demographics

The Baird and McGuire site is located in the western section of Holbrook, 400 feet east of Randolph, one mile northeast of Avon, and approximately two miles northeast and upstream of Braintree (figure A-1). The 1980 U.S. Census indicated that 11,140, 28,218, 5,026, and 36,337 individuals live within the towns of Holbrook, Randolph, Avom, and Braintree, respectively. The racial and age breakdown of the two towns

(Holbrook and Randolph) and the two census tracts (Holbrook 4211 and Randolph 4203) closest to the site are given in Table I. The closest residences are located approximately 675 feet west of the site across South Street [26]. In the Summary of Remedial Alternative Selection (September 29, 1986), the EPA estimated the residential (R) and nonresidential (NR) population for the following radial distances: 0-1,000 feet, 117 R, 280 NR; 1,000-2,000 feet, 826 R, 178 NR; and 2,000-5,280 feet, 9,067 R.

The towns of Holbrook, Randolph and Braintree have been supplied with potable water from the Great Pond Reservoir system. According to EPA's determinations, 77,841 residents and 114,841 nonresidents are being served by the above-mentioned reservoirs for their potable water needs. Three schools in Holbrook (Summer School, Garfield Road School, and Union Street School) and one school in Randolph (Martin E. Young School) are within a 1-mile radius of the site. In Holbrook, a nearby private kindergarten has been open since 1965. Two other Randolph schools, the Stetson and McNeil Schools, are located within a 1-mile radius, but have been closed for several years. Currently, the Stetson School is used as a senior citizen center. Between a 1-mile and a 2-mile radius of the site, there are 7 schools in Holbrook (Franklin St. School, Belcher St. School, Saint Joseph School, South School, John F. Kennedy School, and the Junior and Senior High Schools), 5 schools in Randolph (Saint Mary's School, Belcher School, Lyons School, J.F.K. Junior High School, and Randolph High School), 3 schools in Avon (Crowley School and the Junior and Senior High Schools), and one school in Braintree. The Saint Mary's School, at one time a parochial grade school, is currently the site of a private preschool and an after school care facility.

The Norfolk County Hospital in Braintree is located within the 2-mile radius of the site. A retirement community, the Glovers Brook Apartments, is located within the 2-mile radius in Randolph.

Table I

Demographic Characteristics of Holbrook and Randolph

Characteristic	Randolph		Holbrook	
	Town	CT* 4203	Town	CT 4211
Total Population	28,218	13,156	11,140	4,896
Race:				
White	27,006	12,532	10,794	4,806
Black	855	475	212	41
American Indian	19	13	18	13
Asian	232	5	67	1
Other	106	55	49	21
Age:				
Under 5	1,374	673	679	338
5 - 17	5,885	2,775	2,649	1,192
18 - 61	16,819	7,658	6,628	2,807
62 and over	4,140	2,050	1,184	559
Median Age	33.3		29.5	

* CT, census tract

2. Land Use

Currently, the Baird and McGuire site is fenced to prevent access by unauthorized personnel. It has been reported that, in the past, children used the site as a shortcut walkway and as a place for recreation [86,102]. Adolescents and teenagers played with empty barrels, often climbing into the barrels and rolling down hills, and had throwing fights using a green substance found in the area they called "moon gob". Land use in the immediate vicinity of the site is mainly commercial/industrial; however, much of the wetland areas are forested. The Cochato Industrial Park bounds the site to the east. North of the site is another industrial area consisting of chemical companies (Holbrook Chemical Company, Inc. and/or Phillips Brothers Chemical Company, Inc.). A variety of industrial activities are practiced in the vicinity of the site and include metal processes (engraving, plating, and fabrication), materials research, paint production and spray painting, chemical storage, and leather cutting.

On the southern boundary, undeveloped open space is located, and consists of wooded wetland (southeast) and the South Street Wellfield (south). Residential areas are located across South Street southwest and west of the Baird and McGuire site. A half-mile southeast of the site and surrounding Lake Holbrook is located another residential area, the Grove neighborhood. As the distance increases away from the site, the land use becomes predominantly residential, especially to the west in Randolph.

Within the DEP's "List of Confirmed Disposal Sites and Locations to be Investigated, October 1989," nine sites in Randolph and eleven sites in Holbrook have been entered. This list is generated in accordance to Massachusetts General Laws Chapter 21E and the Massachusetts Contingency Plan (310 Code of Massachusetts Regulations 40.00). The nine sites in Randolph consist of five confirmed sites (4 petroleum release sites and 1 hazardous material/petroleum release site), three locations to be investigated, and one remediated site. The eleven Holbrook sites consist of five confirmed sites (Baird and McGuire site; Adolph Bauer Co. next to the Baird and McGuire site at 763 South Street - this site is a hazardous material release site; and three petroleum release sites), five locations to be investigated, and one remediated site (Serta/Northeast at 12 Mear Road where a removal of contaminated material occurred and periodic monitoring is on-going). Adolph Bauer Co. and Serta/Northeast are the two sites located closest to the Baird and McGuire site. Adolph Bauer Co. is located south of the site and west of the South Street Wellfield. Serta/Northeast is located north of the site across the Cochato River.

3. Natural Resource Use

a. Municipal Water Supply

Historically, the Towns of Holbrook and Randolph have obtained municipal potable water from three distinct sources:

(1) Great Pond/Upper Reservoir/Richardi Reservoir

About three miles downstream of the site in Braintree, the Cochato River flows past the Richardi Reservoir. The Richardi Reservoir is a man-made supplementary water supply first utilized in the early 1970's. A sluice gate was installed at about this same time in order to permit and regulate the diversion of surface water from the Cochato River to the Richardi Reservoir. This sluice gate was closed in 1983 because of the

break in the creosote containment barrier at the BMCCI facility. The gate has remained closed since 1983.

Surface waters from the Richardi Reservoir are pumped to the Upper Reservoir (located in Randolph and Braintree) whenever the water level in the Upper Reservoir is low. Pumping occurs two or three times per year usually during the summer, and averages about 1 billion gallons per year. The Upper Reservoir is separated from the Great Pond (located in Braintree and Randolph) by a man-made dike, and water flows from the Upper Reservoir to Great Pond by gravity.

The Great Pond/Upper Reservoir was first used as a water supply by the Towns of Braintree, Randolph and Holbrook in the mid to late 1880's, and, currently, is the sole source of municipal water, as supplemented by water from the Richardi Reservoir when needed, by the three townships. Randolph's pumping station supplied water to Randolph and Holbrook at the rate of 1.08 to 1.54 billion gallons per year for the years 1980-1988. Braintree has its own pumping station, and, during the same period, pumped water at a rate of 1.38 to 2.28 billion gallons per year.

Water enters Holbrook from Randolph via an interconnection at Union Street, and is delivered to a booster station on Union Street. A municipal water main that distributes water from the booster station to the South Street/Brookville section of Holbrook used to cross the site between the BMCCI and the undeveloped portion of the New Can Company Inc. property. The water main has been relocated off-site to South Street, because, during most of the year, the water table was above the top of the water pipe, and the ground water was found to be highly contaminated and caustic. During the Phase I RI, monitoring of water samples from the water main prior to its relocation did not reveal chemical contamination. Another interconnection (gate valve) between the water supplies of the two towns is located on South Street, but is usually closed to keep Holbrook's water from backfeeding into Randolph. Water statistics records indicate that this interconnection was last open in 1980.

(2) South Street Wellfield

The South Street wells are three gravel packed wells installed in outwash at depths of 53 to 61 feet. The wells are located 1,000, 1,280, and 1,500 feet south of the BMCCI facility. The wells first went on-line in the mid to late 1950's.

The well closest to the site (#3) was the last to go on-line (October, 1958) and had the highest potential yield (about 1,000 gallons per minute [gpm]). This well was only on-line until early 1959 when phenol contamination was discovered. Tests conducted on behalf of the Town of Holbrook by Northeast Consultants during the period 1959-1961 indicated that the source of contamination was from the BMCCI facility and was present in soil borings south of well #3 and north of well #2. Records obtained by E.C. Jordan from the Randolph Water Department indicated that well #3 was pumped during 1968 at a rate of 0.16 million gallons per day [21]. Well #3 was shutdown until about 1978, when the well was reactivated and pumped to waste (1978-1980), i.e., to the ground surface in the southern wetlands, in an effort to cleanse the aquifer of contaminants. There is uncertainty as to whether the well went on-line for a one month period in 1978. Records obtained by E.C. Jordan from the Holbrook Public Works Department do not indicate that well #3 was pumped to waste in 1977 (0.10 million gallons per day) and 1979 (0.09 million gallons per day), and may have been on-line. According to the Superintendent of the Holbrook Department of Public Works, well #3 was never on-line after 1959 [111].

Well #2 is located 1,280 feet south of the site, and was operated intermittently when needed for emergency periods (e.g., summer water shortage) from the mid-1950's until 1980. According to the records obtained by E.C. Jordan, there is no indication that well #2 was pumped after 1965. Records prior to 1966 gave the total volume and rate pumped from the South Street wellfield, not for the individual wells. This well had a potential yield of 250 gpm. When not in use, this well was shut down so that contaminated water would not be drawn towards and captured by the well. In April 1980, both wells #2 and #3 were permanently closed as a result of a spot check by the DEQE for select volatile organic compounds (VOC's) which detected contaminants above drinking water standards.

Well #1 is located furthest from the site, and has a potential yield of 175 gpm. This well operated continuously from the mid-1950's until 1980 when pumped to waste as a result of the DEQE's spot check program. This well was put back on-line in the spring of 1981 contingent upon the DEQE requirement that the water be monitored twice yearly. Well #1 was permanently shutdown on February 3, 1982 when an oily substance (creosote) was discovered on the Cochato River and when a site inspection by DEQE showed improper waste

disposal practices at the BMCCI facility. When on-line, the South Street wells were thought to supply water to part of South Street, the Grove area, and the Brookville area of Holbrook.

(3) Donna Road Wellfield

The Donna Road wellfield is located south of the Grove area, and is separated from the site by Lake Holbrook. Twenty shallow wells (about 40 feet deep) were installed, and, beginning in 1966, were pumped into the system continuously except during periods of mechanical difficulties (air would get into the lines and the pumps would lose prime). About 350,000 gallons per day were pumped from the wellpoints in this wellfield. The water from this wellfield is high in iron and manganese, and, based upon customer complaints, the water was distributed to the southern part of town along South Franklin Street and the Revere section of town. The nearby Grove area appeared not to receive water from this wellfield. The wells were closed in 1981 due to mechanical problems and iron and manganese contamination. Based on the final ROD signed in September, 1990, the EPA plans to reactivate this wellfield to replace the Lost Demand due to the closure of the South Street wells.

b. Private Water Supply

According to the Holbrook Board of Health records, ten private wells are used for domestic potable water and 49 private wells are used only for watering gardens. Information supplied by the Randolph Board of Health indicates the known existence of 104 private water supply wells in Randolph. A water restriction, which varies in severity at times, exists in Holbrook and Randolph. Conservation measures have included a ban on the outdoor use of municipal water for swimming pools, washing cars and windows, and, during most hours, the watering of lawns and gardens; therefore, the proportion of the wells used for purposes other than as a potable supply are not known (e.g., gardening and swimming pool). No other information is available for private water supply wells located in either township (e.g., the installation depths of the wells or whether the wells were installed in bedrock or overburden). Although required by state law to report the installation of private domestic water supply wells to the local board of health, it should be emphasized that the ownership of these wells is self-reported and that other wells may exist. Enforcement of this law among towns within the state is variable. The existence of

older private wells is particularly likely to be unknown.

In Holbrook, one domestic water supply well is located about 1/4-mile southeast of the site on English Road. Four domestic water supply wells are located between one-half and one mile of the site in the Grove area. The garden use wells are scattered throughout Holbrook with several located about one-half to one mile from the site.

In Randolph, one private well is located about one-half mile north-northeast of the site near Union Street. Two private wells are located about three-quarters of a mile northeast of the site not far from the Cochato River. An additional 6 private wells are located between three-quarters and one mile west and northwest of the site. Three other wells are located to the north just outside the one mile radius. An industrial well was installed in the fall of 1985 at the Accurate Metal Finishing, Inc. facility on South Street, and is located approximately 500 feet northwest of the site. This well is not used for potable water.

c. Fishing, Hunting and Farming

Fishing, hunting and trapping are recreational activities in some areas along the Cochato River, especially at Sylvan Lake located about 2,000 feet north of the Baird and McGuire site and in the wetlands downstream from the lake. Past activities at the site include blueberry picking and hunting. Swimming/wading by children also occurs during the summer, although it is unlikely to occur near the site because of the shallowness of the Cochato River. Swimming/wading is more likely to occur in Lake Holbrook, and, perhaps, in the Sylvan Lake and the Ice Pond. The pasture south of the site and east of the South Street Wellfield was once a farm with dairy cows. The last year the farm was in existence is unknown, but may have been during the 1950's.

D. State and Local Health Data

Health outcome data reported were obtained from three existing studies and one study conducted as part of the Public Health Assessment process. All of the studies used existing MDPH data bases and were analyzed descriptively. The first study, which was conducted by the MDPH in 1986, evaluated cancer mortality and incidence for the towns of Holbrook and Randolph [78]. Cancer mortality data for the years 1969-1983 were obtained from the mortality records filed in the MDPH's Registry of Vital Records

and Statistics. Cancer incidence data for the period 1982-1983 were obtained from the MDPH Cancer Registry.

The second study updated the 1986 study and was conducted as part of this Public Health Assessment. Cancer incidence data for the years 1982-1986 were obtained from the Cancer Registry, and included types of cancer determined to be of concern based upon the available scientific literature and community concerns. Analyses were made at the census tract level for both communities. Residential and occupational histories for some cancer cases were ascertained from Randolph (1964-1989) and Holbrook (1939-1989) annual resident's and voter registration listings.

The third MDPH study was of adverse birth outcome during the period 1980-1984 for the towns of Holbrook and Randolph and five neighboring communities [79]. Data bases utilized were the fetal and infant deaths from the mortality records. Birth events, congenital anomalies, and low birth weights were obtained from the birth records from the Registry of Vital Records and Statistics (RVRS). In all three investigations conducted by the MDPH, population data were obtained from the Regional Office of the U.S. Census.

The final study was reported by researchers at the Harvard School of Public Health in 1989 [20]. This study investigated a perceived cancer cluster in an area of Randolph (i.e., Bartlett/Green Acres). The original list of putative cancer cases were compiled by the residents of the area. This data was supplemented by cases obtained from the MDPH's Cancer Registry. Cancer deaths were obtained from the residents' compilation, death certificates at the Randolph town hall, and the computerized mortality file at MDPH's RVRS. To determine the population of the area, the annual town census (1964-1984) was used. Generally, an adult from each residence of a cancer case was interviewed to obtain case specific information.

Community Health Concerns

Community concerns regarding the Baird and McGuire site are evident because of various groups' involvement with site-related issues, the numerous newspaper articles regarding alleged health impacts, and the number of correspondences received by state and federal regulatory and health officials. The citizen and private sector groups historically involved with the site are:

1. PURE, People United to Restore the Environment. This group was initiated by citizens from Holbrook and Randolph as a result of their concerns regarding the possible health effects following exposure to Baird and McGuire site contaminants. This group is responsible for collecting over

1,000 signatures on a petition endeavoring EPA to address various issues relative to the Baird and McGuire site. Issues of concern to the Public Health Assessment are the fencing and posting of the site to protect residents and others from contact with the site, and a health survey to be contracted "to determine the magnitude of health problems in Holbrook neighborhoods and nearby towns."

2. Clean Water Action Project. This group is a nationally organized coalition of environmental advocates who advised and supported PURE at various times.

3. Citizen's Task Force. This group was established in 1986 by the Holbrook Board of Selectmen to interface with EPA (and other state and local government agencies) regarding the Baird and McGuire site remediation process. Members of the Citizens' Task Force include (1) local officials from the towns of Holbrook, Randolph, and Braintree; (2) concerned citizens from these communities; (3) representatives from PURE and the Clean Water Action Project; and (4) two state legislators. Historic concerns expressed by the Citizen's Task Force and the community include: (1) the quality and safety of the drinking water; (2) continued participation by the task force in public health issues, etc.; and (3) the development of an education program to teach students about the dangers of the site and the progress of cleanup activities. The Citizen's Task Force remains the most active group at the site.

4. Grove Association of Holbrook. This group consists of residents living in the development termed the Grove that surrounds Lake Holbrook. This development is located near the Baird and McGuire site and the South Street Wellfield.

   Topics especially expressed as being of public health concern include: (1) the health impact of site-related contaminants to children who played with empty drums and green "moon gob" found near the site, workers at the facility (according to one town official, the workers at the facility often would mix the batches of chemicals with their bare hands, and many of the workers had no fingernails), local residents from South Street and the Grove area, and people who drank municipal water, especially water from the South Street Wellfield; and (2) the contamination of water sources used for municipal water supplies, i.e., the South Street Wellfield and the Cochato River which, in the past, was diverted to the Richardi Reservoir (a supplemental water supply used mostly during the summer).

   Particular health issues have been reported in the local and Boston news media. According to one report, eight young adults (less than 30 years of age) were diagnosed as having

cancer or other disease within a three year span of time. As children, all eight individuals attended the same schools, lived in the same neighborhood, and played near the Baird and McGuire site. The diseases reported were Hodgkin's disease (3 cases), leukemia, melanoma, brain tumor, adrenal cancer, and sarcoidosis. Five of these individuals died prior to May, 1983. Other news reports told of an alleged relationship between chronic endocrine problems and weakened immune systems and playing near the site, and of a perceived increase of cancer and reproductive problems (including miscarriages, sterility, and birth defects) in nearby residents. Thirty-five individual lawsuits have been filed by families against the BMCCI and its insurance companies for health problems allegedly stemming from exposure to Baird and McGuire contaminants.

As a result of the citizens' health concerns, the MDPH's Center for Health Promotion and Environmental Disease Prevention conducted two health studies in 1985. The first study was on cancer mortality (1969-1983) and cancer incidence (1982-1983), and the second study was on adverse birth outcome data for Holbrook and surrounding communities (1980 - 1984). The findings of these two studies are given in the portion of the "Public Health Implications" section entitled "Health Outcome Data Evaluation."

Continued community interest in Baird and McGuire site activities is evident by the requests to the MDPH for local meetings with the Randolph and Holbrook Health Agents who represent their respective Boards of Health, and with the Holbrook Board of Selectmen. The requests for meetings came as a result of the MDPH process of informing the affected communities of the intent to conduct a Public Health Assessment at a nearby NPL site. On September 25, 1989, an MDPH representative met with the Randolph and Holbrook Health Agents to define the Public Health Assessment process and to inform them of where in the process their participation is requested. As a result of this meeting, information was obtained from the Health Agents on private well locations, school locations, the municipal water supply sources, and historical background for the facility and the site.

On October 2, 1989, MDPH representatives met with the Holbrook Board of Selectmen to define the Public Health Assessment process, why it is being conducted, and to inform them of how and when the community is involved in the process. Also attending the meeting were the Holbrook Health Agent, the Superintendent of the Holbrook Department of Public Works (who is also the Chairman of the Randolph-Holbrook Joint Water Board and a member of the Baird and McGuire Task Force), and the President of the Grove Association of Holbrook. Members of the Board of

Selectmen expressed strong interest in the Public Health Assessment, and requested that the MDPH actively involve the Task Force and the Health Agent in order to keep them apprised of the progress of the Public Health Assessment and to learn their concerns.

On November 30, 1990, during a public meeting, the MDPH announced the availability of the Public Health Assessment for public comment. During the public comment period for this document, which ended on January 1, 1991, a number of citizens expressed health and exposure concerns (see Appendix E, Public Comment Period--Technical Correspondence). These concerns include possible effects from playing or working at the site, consuming South Street water, future incineration of site contaminants, ingestion of game animals or fish. Specific health concerns expressed were skin disorders in people who worked at the site; immune disorders, endocrine, adrenal, reproductive problems, non-Hodgkin's lymphoma in young adults who played at the site as children; and cancer especially non-Hodgkin's lymphoma in people who lived in the vicinity of the site then moved away prior to diagnosis. A number of people expressed interest in a follow-up study and development of a screening mechanism for non-Hodgkin's lymphoma. The need was expressed for public involvement in all subsequent follow-up activities. Since the end of the public comment period, the MDPH has conducted several public meetings to review health concerns related to the site and to initiate discussions related to follow-up health activities (May 1991).

Environmental Contamination and Other Hazards

A. On-Site Contamination

1. Ground Water

The ground water monitoring data reviewed for this Public Health Assessment were obtained from studies conducted following the installation of the ground water recirculation system and the clay cap. The major ground water monitoring studies were conducted during the Phase I [43] and II RIs [42] and the field investigation for the Focused Feasibility Study (the Cochato River Sediment Study) [22].

The Phase I study entailed the monitoring of ground water from 48 newly installed monitoring wells in fifteen locations and from fifteen monitoring wells of the previously existing 45 monitoring wells in 38 locations. A total of seventy samples were collected and 42 were monitored for Hazardous Substance List (HSL) inorganic and

organic compounds. All but two monitoring well locations were on-site.

During the Phase II ground water investigation, ten monitoring wells and six gas-driven samplers were installed in nine locations. Sixty-five samples from these new installations and from monitoring wells at eighteen previously installed monitoring locations were monitored for HSL constituents. All but five monitoring well locations were on-site. In order to determine the quality of the ground water discharging from inorganic and organic sediments into the Cochato River, three seepage meters were installed in the bed of the Cochato River. A mini-piezometer was installed next to each seepage meter at a depth of 5.0 feet (for inorganic sediments) and were monitored for ground water quality. Each sample was monitored for chlorinated and aromatic organic compounds.

The Cochato River Sediment Study's ground water monitoring program consisted of all on-site samples from the Cochato River and from the wetland area serving as the western bank of the Cochato River. During April 1988, seven existing shallow monitoring wells and two seepage meters were monitored for Target Compound List (TCL) organic compounds and metals.

The on-site results of the ground water monitoring studies are summarized in Tables C-1A and C-1B. For ease of presentation, the site is divided into nine major areas:

1. the tank farm/facility area - now mostly demolished and covered with a synthetic cap;

2. the clay cap area - formerly the site of the creosote lagoon, barrel and contaminated soil disposal;

3. the unnamed brook and the associated northern wetlands;

4. the southern wetlands;

5. the seasonally wet area;

6. the western site area;

7. the Cochato River;

8. the western bank/wetlands of the Cochato River; and

9. the eastern bank/wetlands of the Cochato River and nearby woodlot.

The contamination for areas 1 and 2 is summarized in Table C-1A, and for areas 3-9 in Table C-1B. The known levels of contamination for the compounds of concern (the most prevalent and/or toxic compounds associated with the site for which the potential for human exposure existed, exists, or will likely exist in the future) for each area is briefly described below.

Monitoring of ground water in areas 1 (former tank farm/facility area) and 2 (clay cap area) as part of the Phase I and II RIs occurred from five monitoring wells in three locations. Monitoring Well RW1 is one of two recovery wells for the ground water recirculation system and is located east of the clay cap. This well was monitored during the Phase II RI and was found to contain many of the contaminants of concern, i.e., 220 parts per billion (ppb) benzene, 8.5 ppb trichloroethylene, 140 ppb vinyl chloride, 1100 ppb ethylbenzene, 4700 ppb total xylenes, 1800 ppb 2,4-dimethylphenol, 6100 ppb polycyclic aromatic hydrocarbons (PAHs) (mostly naphthalene and 2-methylnaphthalene), 0.18 ppb dieldrin, 3.7 ppb 2,4-dichlorophenoxyacetic acid (2,4-D), 537 ppb arsenic, and 9.0 ppb 2,4,5-trichlorophenoxyacetic acid (2,4,5-T).

The second location is near the storage building and immediately east (downgradient) of the five ground water recharge chambers. Two bedrock Barcad samplers from one monitoring well (43.5 and 53.5 foot depths from ground surface) and one overburden monitoring well (screened at 18-28 feet) were monitored during either the Phase I or II RI. Contaminants were detected at all three depths, but were highest in the overburden monitoring well. For the overburden monitoring well, the contaminants and levels detected were generally about the same as for the recovery well, RW1. PAHs (20,500 ppb), dieldrin (9.9 ppb), 2,4-D (18 ppb), 2,4,5-T (18 ppb), and arsenic (1950-3450 ppb) were detected in higher concentrations than for RW1. Various insecticides [2.8 ppb 4,4'-dichlorodiphenyltrichloroethylene (4,4'-DDE), 53 ppb 4,4'-dichlorodiphenyldichloroethane (4,4'-DDD), 32 ppb chlordane, 8.7 ppb lindane (gamma-benzene hexachloride or gamma-BHC), and 1.6 ppb alpha-benzene hexachloride (alpha-BHC)] were detected here but not at RW1.

The third location is situated south of both capped areas and near the dirt access road. This shallow overburden monitoring well (4-13.6 feet) was monitored during the Phase I investigation. Ground water from this well contained 0.95 ppb 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT), 0.55 ppb 4,4'-DDE, 12 ppb 4,4'-DDD, 0.40 ppb dieldrin, 0.57 ppb chlordane, and 0.06 ppb lindane.

Area 3 encompasses the area bordering the unnamed brook and the associated northern wetlands. Seven monitoring wells at five locations were monitored during the Phase I and II RIs. Two of the monitoring wells were bedrock wells. The overburden well (BM11) in this area that contained the greatest number and concentration of contaminants is located near the laboratory building. This monitoring well contained 27 ppb benzo(a)pyrene, 172 ppb fluoranthene, 617 ppb PAHs (other), 10 ppb 4,4'-DDT, 9.8 ppb 4,4'-DDE, 120 ppb 4,4'-DDD, 2.4 ppb dieldrin, 25 ppb chlordane, and 740 ppb arsenic. The remaining overburden wells contained lesser amounts of contamination, with the most prevalent contaminants being 4,4'-DDD (0.38-6.9 ppb), chlordane (0.90-48 ppb), lindane (0.78-4.2 ppb), alpha-BHC (0.37-1.8 ppb), and arsenic (6.6-52 ppb). The two bedrock monitoring wells contained low levels of DDT (and related compounds) and chlordane.

Area 4 is located in the southern wetlands. One bedrock and four overburden monitoring wells in four locations were monitored for ground water contaminants. Trace levels of contaminants were detected in the overburden wells. Monitoring Well BM5-2 is located near the dirt access road and contained 254 ppb arsenic. The bedrock well (904) contained 0.14 ppb 4,4'-DDT, 0.025 ppb 4,4'-DDD, and 0.61 ppb chlordane.

Area 5 is located in the seasonally wet area immediately west of the dirt access road. One overburden monitoring well was monitored during the Phase I and II RIs. The only contaminants of concern detected were 16 ppb benzene, 0.90 ppb dieldrin, and 0.31 ppb 2,4-D during the Phase II RI.

Area 6 is comprised of the western site area located between the tank farm and South Street. Bedrock Monitoring Well 908 was monitored during the Phase I investigation and was determined to contain 40 ppb PAHs, 0.36 ppb 4,4'-DDT, and 0.16 ppb 4,4'-DDD. During the Phase II RI, two bedrock monitoring wells were monitored, and Monitoring Well 908 was found to contain 0.20 ppb 2,4,5-T.

Area 7 is located in the part of the Cochato River located on-site. During the Phase II RI, three seepage meters and three 5 foot peizometers were installed and monitored for chlorinated and aromatic volatile organic compounds. The sampling stations were located (1) upstream of the clay cap near the southern wetlands, (2) immediately east of the clay cap, and (3) downstream of the unnamed stream. At the first location, ethylbenzene (4.0 and 2.1 ppb) and total xylenes (9.9 and 2.2 ppb) were detected in both the seepage meter and piezometer (respectively). At the location nearest the clay cap, the seepage meter contained 180 ppb ethylbenzene,

710 ppb total xylenes, and 55 ppb benzene. The piezometer sample contained 223 ppb ethylbenzene, 1150 ppb total xylenes, and 59 ppb benzene.

During the Cochato River Sediment Study, the first and third seepage meters were resampled and monitored for TCL constituents. The first location contained trace levels of PAHs, and the third location contained 960 ppb arsenic.

Area 8 is located in the wetland area along the western bank of the Cochato River. During the Phase I RI, five overburden and two bedrock monitoring wells in four locations were monitored. The bedrock and overburden monitoring wells at location 912 south of the southern wetland contained little or no contaminants of concern. The sample from the overburden monitoring well contained 0.66 ppb 4,4'-DDD and 3.4 ppb cadmium. The two monitoring well stations located near the clay cap and south of the unnamed brook contained the highest levels of the contaminants of concern. The three overburden wells in this area contained benzene (84-210 ppb), vinyl chloride (160 ppb), ethylbenzene (290-520 ppb), total xylenes (590-2300 ppb), 2,4-dimethyl-phenol (290-2400 ppb), PAHs (1300-6500 ppb) consisting mostly of naphthalene and 2-methylnaphthalene, 4,4'-DDT and related compounds (1.26-1.96 ppb), alpha-BHC (0.50 ppb), and arsenic (25-3850 ppb). The bedrock monitoring well located near the clay cap contained lower levels of vinyl chloride (19 ppb), benzene (26 ppb), ethylbenzene (77 ppb), total xylenes (125 ppb), 2,4-dimethylphenol (150 ppb), PAHs (541 ppb) mostly naphthalene 2-methylnaphthalene, and dieldrin (0.10 ppb), chlordane (0.50 ppb), 4,4'-DDT (0.10 ppb), and 4,4'-DDD (0.10 ppb). Overburden Monitoring Well 910B located north of the unnamed brook contained 1.1 ppb 4,4'-DDT, 0.15 ppb 4,4'-DDE, and 0.25 ppb 4,4'-DDD.

The Phase II ground water investigation in this area consisted of the monitoring of six overburden and two bedrock monitoring wells. The overburden monitoring well located south of the southern wetlands contained no detectable levels of the contaminants of concern. The overburden monitoring well located near the clay cap contained similar, although somewhat higher, levels of contaminants than during the Phase I investigation. In addition, 3.8 ppb 2,4-D and 9.0 ppb 2,4,5-T were detected in this well. A new monitoring well station (919) located immediately north of the unnamed brook contained 5 ppb benzene and 980 ppb arsenic in its shallow overburden well (5-15 feet deep) and 1.4 ppb 4,4'-DDD, 1.2 ppb dieldrin, and 10 ppb chlordane in the deep overburden well (26-30 feet deep). Monitoring Well Station 910 is located north of Station 919 and contained no detectable levels of the contaminants of concern in its bedrock well and 0.06 ppb

4,4'-DDT, 0.06 ppb 4,4'-DDD, 0.03 ppb dieldrin, and 0.09 ppb chlordane in its overburden well. Another new monitoring station was installed between Station 910 and Mear Road. The bedrock well contained 5 ppb trichloroethylene. The overburden well contained 10 ppb vinyl chloride, 110 ppb ethylbenzene, 5 ppb total xylenes, and 0.44 ppb 2,4-D.

During the Cochato River Sediment Study, seven shallow overburden monitoring wells were monitored. The two wells located near the clay cap contained benzene (33-140 ppb), ethylbenzene (78-890 ppb), total xylenes (51-2800 ppb), 2,4-dimethylphenol (270-300 ppb), PAHs (460-8049 ppb, consisting mostly of naphthalene and 2-methylnaphthalene), and arsenic (481-3090 ppb). The two monitoring wells located nearest the unnamed brook contained insecticides (1.6 ppb 4,4'-DDT, 40 ppb 4,4'-DDD, 1.6-2.0 ppb dieldrin, and 13.1 ppb chlordane) and arsenic (1420-1860 ppb). The remaining one upstream well and two downstream wells contained no detectable levels of the contaminants of concern.

Area 9 is located east of the Cochato River in the wetlands along its bank and in a woodlot across the river from the clay cap. During the Phase I RI, eleven overburden and three bedrock monitoring wells in ten locations were monitored. Little information was available for volatile organic compounds. The highest level of contamination was detected in the two overburden wells located across from the southern wetlands and the clay cap. Samples from these two wells contained 2,4-dimethylphenol (460-510 ppb), PAHs (5110-6640 ppb), 4,4'-DDE (0.31 ppb), 4,4'-DDD (4.9 ppb), chlordane (0.43 ppb), and lindane (0.15-0.28 ppb). Lesser amounts of these same contaminants were detected in an overburden well located west of the woodlot and almost across the river from the unnamed brook. The bedrock well located along the eastern bank of the river and across the river from the unnamed brook contained 46 ppb benzene, 107 ppb ethylbenzene, 115 ppb total xylenes, and 11 ppb PAHs.

The Phase II investigation consisted of thirteen overburden ground water monitoring locations, of which three samples were from test pits located immediately west of the municipal sewer line and three samples were from shallow monitoring wells installed immediately east of the sewer line. The monitoring well located immediately across the river from the clay cap contained the highest level of the contaminants of concern, i.e., 21 ppb benzene, 67 ppb ethylbenzene, 300 ppb total xylenes, 2100 ppb2,4-dimethyl-phenol, 15700 ppb PAHs consisting mostly of naphthalene and 2-methylnaphthalene, 8.2 ppb 2,4,5-T, and 17 ppb arsenic. The nearby sampling stations straddling the sewer line contained lower levels of contamination, specifically,

benzene (9-21 ppb), ethylbenzene (10-51 ppb), vinyl chloride (18-67 ppb), total xylenes (35 ppb), and PAHs (12-110 ppb). The two sampling locations in (BM 18-2) or near (901B) the woodlot contained benzene (74-180 ppb), vinyl chloride (97-130 ppb), ethylbenzene (150-360 ppb), total xylenes (250-370 ppb), 2,4-dimethylphenol (140 ppb), PAHs (294-919 ppb), dieldrin (0.13 ppb), and 2,4,5-T (0.24 ppb).

2. Soil

The soil data reviewed for this Public Health Assessment was obtained from studies following the soil and barrel removal action (September, 1983) and installation of the clay cap (May, 1984), specifically, the Phase I and II RIs [42,41]. The Phase I RI soil sampling consisted of 48 samples which were collected from 43 mostly on-site locations. Samples were obtained using a split-spoon sampler usually at five foot vertical intervals to a depth of about ten feet. Samples were monitored for HSL organic and inorganic compounds. On-site areas monitored consisted of (1) the tank farm area, (2) the area north of the parking area, (3) beneath the parking lot asphalt, (4) the area north of the laboratory building, (5) the area along the unnamed brook, (6) the areas east of the laboratory, mixing and storage buildings, (7) the seasonally wet area near the dirt access road leading towards the South Street wellfield, (8) the southern wetland, and (9) the wetland located on-site along the western bank of the Cochato River.

Additional Phase I soil monitoring consisted of samples taken from test pits. Seventeen samples were obtained from 17 on-site locations thought to be areas of soil contamination or buried waste. Test pits were dug to a depth of three to eight feet. Twelve samples were selected for monitoring. Areas monitored for soil contamination are: (1) the areas near the mixing and storage building, (2) the area north of the parking lot and adjacent to the unnamed brook, (3) the seasonally wet area adjacent to the dirt access road, (4) the part of the southern wetland which lies just east of the dirt access road, (5) the area west of the site trailer where 55-gallon drums were found to be partially buried, and (6) along the water main that traversed the site. Eleven additional soil samples were obtained during monitoring well installation in eight locations scattered throughout the site and were monitored for the same constituents as the other Phase I soil samples. On July 24-25, 1985, the EPA's Emergency Response Team conducted monitoring of about 30 soil samples obtained from locations scattered throughout the site for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) [8,27].

The Phase II RI soil sampling consisted of 217 samples collected from 79 areas located both on-site and off-site, and monitored for HSL inorganic and organic compounds and herbicide analysis. For twenty-six samples additional monitoring was conducted for the presence of 2,3,7,8-TCDD. Monitoring procedures tended to be the same as for the Phase I RI. However, monitoring depth ranged to a maximum of 32 feet. Most of the 79 locations were on-site, although at least 16 locations were off-site. On-site monitoring areas were located in the plant area, the clay cap area, the northern and southern wetlands, and the seasonally wet area near the dirt access road. The tank farm, the mixing and laboratory buildings, the water main, and the parking area were still in existence at the time of the Phase I and II studies.

On-site soil monitoring data are presented in Tables C-1A and C-1B. These data are a summation of Phase I and II monitoring events, and are modified as presented in the Phase II summary tables (Tables 5-1 to 5-8). Surface soil samples were designated such in the Phase II RI if the sample was obtained within three feet of ground level. A brief description of the contamination detected in each of the on-site areas monitored follows. To this end, the site is divided up into the same nine areas described in the section regarding on-site ground water contamination.

Area 1 (tank farm/facility area) is divided into three subareas for the ease of presentation. The soil monitoring at the tank farm consisted of twelve surface (samples obtained from the first two feet of soil) and nine subsurface (obtained to a maximum depth of twelve feet) soil samples. Generally lower levels of the contaminants of concern were detected in the subsurface soil samples than in the surface soil samples. The maximum levels of the more prevalent surface soil contaminants of concern follow: 1,100 ppb dieldrin; 395,000 ppb chlordane; 669,000 ppb 4,4'-DDT; 66,000 ppb 4,4'-DDE; 22,000 ppb lindane; 26,000 ppb fluoranthene; 1,300 ppb benzo(a)pyrene (only in two surface soil samples); 7,700,000 ppb other PAH's (mostly comprised of naphthalene and 2-methylnaphthalene); 190,000 parts per million (ppm) arsenic; 160,000 ppb total xylenes; and 23,000 ppb ethylbenzene. Tetrachloroethylene, trichloroethylene, benzene, 2,4-dimethylphenol, alpha-BHC, 2,4-D, and 2,4,5-T were detected less frequently and/or at lower levels.

Soil samples from beneath the laboratory, mixing and storage buildings were monitored during the Phase II RI only. The eight samples from beneath the laboratory building were obtained to a maximum depth of 3.5 feet. The maximum levels of the contaminants of concern are: 32,000 ppb dieldrin;

940,000 ppb chlordane; 2,600,000 ppb 4,4'-DDT; 71,000 ppb 4,4'-DDE; 420,000 ppb 4,4'-DDD; 4,200 ppb lindane; 9,000 ppb alpha-BHC; 34,200 ppb fluoranthene; 1,964,000 ppb other PAH's (comprised mostly of naphthalene and 2-methylnaphthalene); 420 ppm arsenic; 29,600 ppb ethylbenzene; 5,100 ppb tetrachloroethylene; 300,000 ppb total xylenes; and 4.40 ppb 2,3,7,8-TCDD. Two soil samples were obtained from beneath the storage building at depths ranging from 2.3-3.8 feet. Contaminants of concern detected were lower levels of the same insecticides and PAH's as beneath the laboratory building, and 22 ppb vinyl chloride. No arsenic or 2,3,7,8-TCDD was detected. Seven samples were obtained from beneath the mixing building to depths of 4.5 feet. The maximum levels detected of the more prevalent contaminants of concern follow: 52,000 ppb dieldrin; 2,200,000 ppb chlordane; 260,000 ppb 4,4'-DDT; 420,000 ppb 4,4'-DDE; 1,300,000 ppb 4,4'-DDD; 26,000 ppb lindane; 8,700 ppb alpha-BHC; 10,100 ppb fluoranthene; 1,779,000 ppb other PAH's (comprised mostly of naphthalene and 2-methylnaphthalene); 928 ppm arsenic; 16,200 ppb ethylbenzene; 570 ppb tetrachloroethylene; 139,000 ppb total xylenes; 8,500 ppb trichloroethylene; 55 ppb vinyl chloride; and 11.3 ppb 2,3,7,8-TCDD.

The final subarea is located around the buildings. Thirteen surface (obtained within three feet of ground surface) and twenty-eight subsurface (obtained to a maximum depth of 22 feet) soil samples were monitored for HSL or TCL organic and inorganic constituents. The maximum levels of the surface soil contaminants of concern are: 138,000,000 ppb dieldrin; 2,800,000 ppb chlordane; 530,000 ppb 4,4'-DDT; 44,000 ppb 4,4'-DDE; 400,000 ppb 4,4'-DDD; 8,400 ppb lindane; 2,500 ppb alpha-BHC; 17,000 ppb 2,4-D; 13,000 ppb 2,4,5-T; 30,000 ppb fluoranthene; 1,500 ppb benzo(a)pyrene; 12,860,000 ppb other PAH's (comprised mostly of naphthalene and 2-methylnaphthalene); 380,000 ppm arsenic; and 9,600 ppb 2,4-dimethylphenol. These same contaminants were also detected at high levels in the subsurface soil samples obtained at depths extending to refusal. Volatile organic compounds were detected at higher levels in the subsurface soil samples (52,000 ppb ethylbenzene; 190,000 ppb total xylenes; and 8,900 ppb tetrachloroethylene).

For area 1, twenty-nine soil samples were monitored for 2,3,7,8-TCDD. Seventeen of these samples were obtained from beneath the previously mentioned buildings. For the entire area 1, twelve samples contained detectable levels of 2,3,7,8-TCDD ranging from 0.19 to 11.3 ppb. The detection limit ranged from 0.05 to 5.75 ppb.

Area 2 is located at and peripheral to the clay cap. During the Phase I RI, ten locations situated between the clay cap

and the Cochato River were monitored to a maximum depth of 57 feet. Four surface soil samples (depth range of 0-2 feet) were monitored in this region of area 2. The maximum level detected of each contaminant of concern follows: 741 ppb dieldrin; 1,256 ppb chlordane; 435 ppb 4,4'-DDT; 61 ppb 4,4'-DDE; 3,576 ppb 4,4'-DDD; 0.78 ppb endrin; 0.80 ppb lindane; 2.2 ppb alpha-BHC; 27,906 ppb PAH's (consisting mostly of 2-methylnaphthalene and naphthalene); 35 ppb ethylbenzene; 20 ppb total xylenes; and 60 ppm arsenic. The samples from locations in the north part of this region contained the highest levels of insecticides. PAHs, specifically naphthalene and 2-methylnaphthalene, were detected in the samples obtained from the central and southern part of this region. Eight subsurface soil samples were obtained from the depth range of 2-8 feet, and five samples were obtained from the depth range of 15-57 feet. Generally, lesser amounts of these same contaminants were detected in the subsurface samples.

During the Phase I investigation, soil from a depth of 8 inches was obtained from a test pit located northwest of the clay cap and near the storage building. This sample was found to contain 170 ppb dieldrin, 740 ppb chlordane, 110 ppb 4,4'-DDT, 57 ppb 4,4'-DDE, and 8.5 ppb lindane.

During the Phase II RI, twenty-one soil samples were obtained from seven locations at the clay cap. All samples were obtained from beneath the cap at depth intervals of two to four feet to a maximum depth of thirty-two feet. All samples were obtained at a depth of five feet or greater, with the exception of one location at the edge of the cap (B89) where the cap material was shallow. In the shallowest samples which would represent surface soils if the cap was not in place, the following maximum levels of the contaminants of concern were detected: 8,600 ppb dieldrin; 32,000 ppb chlordane; 62,000 ppb 4,4'-DDT; 4,200 ppb 4,4'-DDE; 45,000 ppb 4,4'-DDD; 1,800 ppb lindane; 1,500 ppb 2,4-D; 1,300 ppb 2,4,5-T; 1,156,000 ppb other PAHs (comprised mostly of naphthalene and 2-methylnaphthalene); 28,000 ppb ethylbenzene; 11,000 ppb tetrachloroethylene; and 50,000 ppb total xylenes. Samples obtained from depths greater than three feet below the bottom of the cap contained the same contaminants as the surface-most samples. The maximum levels detected were 7,600 ppb dieldrin; 1,200,000 ppb chlordane; 25,000 ppb 4,4'-DDT; 15,000 ppb 4,4'-DDE; 170,000 ppb 4,4'-DDD; 2,300 ppb lindane; 240 ppb 2,4-D; 11,000 ppb fluoranthene; 1,650,000 ppb other PAHs (comprised mostly of 2-methylnaphthalene and naphthalene); 160,000 ppb ethylbenzene; 750,000 ppb total xylenes; 300 ppb tetrachloroethylene; 7,100 ppb 2,4-D; 9,000 ppb 2,4,5-T; and 114 ppm arsenic. Contaminants were detected at elevated

concentrations in the soil sample obtained at the greatest depth (30-32 feet below ground surface).

Monitoring for 2,3,7,8-TCDD resulted in detection in two of eight soil samples from this area. The levels detected are 0.37 and 0.42 ppb.

Area 3 is comprised of the region encompassing the unnamed brook and the associated northern wetlands. For the purpose of presentation this area is divided into two sub-areas: (1) the unnamed brook area and (2) the northern wetland. During the Phase I RI, seven samples from seven locations were monitored for contaminants. Of these samples, two were obtained from depths greater than four feet below ground surface, and the remaining samples were obtained from depths of two feet or less. During the Phase II RI, fifteen samples were obtained from six locations. Six samples were obtained from a depth interval of 0-2 feet below ground surface, and the remaining samples from depths between four and seventeen feet below surface level. The maximum levels detected of the more prevalent contaminants of concern are: 26,200 ppb dieldrin; 25,100 ppb chlordane; 23,000 ppb 4,4'-DDT; 2,100 ppb 4,4'-DDE; 20,000 ppb 4,4'-DDD; 55,000 ppb fluoranthene; 9,000 ppb benzo(a)pyrene; 82,000 ppb other PAHs (at times comprised mostly of naphthalene and 2-methylnaphthalene); 2,100 ppb 2,4-dimethylphenol; and 5,700 ppm arsenic. Usually lower levels of contaminants were detected in the subsurface samples. These samples contained mostly insecticides (chlordane, 4,4'-DDT and breakdown products, and dieldrin) and, less often, PAHs.

The northern wetland monitoring during the Phase I RI consisted of eleven samples from eight locations, of which, five were obtained from a depth interval of 0-2 feet below ground surface and the remaining samples from depths to 53 feet below ground surface. During the Phase II RI, thirty-four samples from eight locations were monitored to a maximum depth of seventeen feet below ground surface. The insecticides (dieldrin, chlordane, and 4,4'-DDT and its breakdown products) were detected in both the surface and subsurface soil samples. The remaining contaminants of concern were detected in the surface soil samples. The maximum level detected of the contaminants of concern are 32,000 ppb dieldrin; 1,700,000 ppb chlordane; 240,000 ppb 4,4'-DDT; 47,000 ppb 4,4'-DDE; 1,100,000 ppb 4,4'-DDD; 2,000 ppb fluoranthene; 1,600 ppb benzo(a)pyrene; 340 ppb 2,4,5-T; 22,500 ppb other PAHs; and 1,000 ppm arsenic. In this area, 12 out of 24 soil samples contained levels of 2,3,7,8-TCDD ranging from 0.44 to 48 ppb.

The southern wetlands comprise area 4. During the Phase I investigation, seven samples were obtained from five

locations in the southern wetlands. Of these samples, four were obtained from the 0-2 foot soil interval and the remaining samples from depths ranging from four to ten feet below ground surface. The Phase II soil investigation consisted of monitoring of soil samples from ten locations. Ten samples were obtained from the 0-1 foot soil interval and twenty-one samples were obtained from depths ranging from four to twenty-two feet below ground surface. The surface-most samples contained most of the contamination detected. Most of the remaining contamination was detected in samples obtained within the four to six foot soil interval. The maximum levels detected of the contaminants of concern are: 1,800 ppb dieldrin; 28,100 ppb chlordane; 82,900 ppb 4,4'-DDT; 10,800 ppb 4,4'-DDE; 34,000 ppb 4,4'-DDD; 170 ppb 2,4-D; 1,400 ppb fluoranthene; 5,000 ppb PAHs; and 70 ppm arsenic. The only samples containing detectable levels of 2,4-D were obtained at two locations at depths of 10-12 feet (91 ppb) and 4-6 feet (170 ppb) below surface level. None of the eight samples monitored contained detectable levels of 2,3,7,8-TCDD.

The seasonally wet area bordering the dirt access road leading to the South Street wellfield comprises area 5. During the Phase I RI, six locations were monitored for contaminants. Four soil samples were obtained from depths to four feet. Two samples were obtained in the 5-6 foot soil interval. The Phase II investigation consisted of four samples obtained within three feet of ground surface and nine samples obtained at depths ranging from three to twenty-two feet. There were four monitoring locations. The maximum levels detected of surface (0-4 foot depths) and subsurface (5-22 foot depths) soil samples are, respectively: 1,200 ppb and 80 ppb dieldrin; 12,000 and 980 ppb chlordane; 260,000 and 22,000 ppb 4,4'-DDT; 11,000 and 370 ppb 4,4'-DDE; 130,000 and 4,100 ppb 4,4'-DDD; 6,000,000 ppb and none detected fluoranthene; 18,000 ppb and none detected benzo(a)pyrene; 10,300,000 and 1,330 ppb other PAHs; and 155 and 155 ppm arsenic. Two of three samples monitored contained 0.07 and 0.74 ppb 2,3,7,8-TCDD.

Area 6 is located in the western site area between the tank farm and South Street. No soil monitoring data are available for this area.

Area 7 is the section of the Cochato River located within the site boundaries. Sediment monitoring data are summarized in the section regarding on-site sediment contamination.

Area 8 is located along the western bank of the Cochato River. The soil monitoring data for this area are summarized in the areas 2, 3 and 4 discussions.

Area 9 is comprised of the eastern bank of the Cochato River and the woodlot across the river from the clay cap. During the Phase I investigation, three samples from two locations were monitored. Two samples were obtained from a depth interval of 35-37 feet and one sample from a depth interval of 5-7 feet. No elevated levels were detected of the contaminants of concern.

3. Surface Water

On-site surface water monitoring was conducted on June 26 and October 4, 1984 during the Phase I RI [43], on February 26, 1986 during the Phase II RI [42], and from May 1983 to March 1985 to assess the effect of the ground water recirculation system [46]. On June 26th, seven locations along the Cochato River (of which 5 locations are on-site) and two on-site locations in the unnamed brook were monitored for total arsenic levels. Two additional locations on the Cochato River (one immediately upstream of the site and one downstream of where the unnamed brook drains into the Cochato River) were monitored for HSL organic and inorganic compounds on June 26th and October 4th. On-site surface water data for the contaminants of concern are summarized in Table C-1B.

One of the locations in the unnamed brook contained surface water arsenic levels of 87 ppb. The only on-site Cochato River sample containing a detectable level of arsenic was the June 26, 1984 sample obtained at location SW6 located immediately downstream of the unnamed brook. Lead levels of 4.2 and 5 ppb were detected at this same location. On October 4th, 2-methylnaphthalene (20 ppb) and naphthalene (20 ppb) were detected resulting in a PAH level of 40 ppb at this location. No other contaminant of concern was detected at location SW6 during either monitoring event.

During the Phase II RI, three on-site Cochato River surface water samples were monitored for chlorinated and aromatic volatile organic compounds. The samples were obtained at locations adjacent to the seepage meters described in the section in on-site ground water contamination. Of the contaminants of concern, ethylbenzene (38 ppb) and total xylenes (790 ppb) were detected in the surface water sample taken from the seepage meter location closest to the clay cap area. The remaining two samples did not contain detectable levels of any of the contaminants of concern.

During the period May 1983 to March 1985, four on-site locations and one off-site location were monitored for contaminants. The locations and times of sampling for the on-site locations are as follows: (1) one unnamed brook location (5/83); (2) one location in a small stream, which

is located in the wetland between the clay cap and Cochato River and which discharges into the unnamed brook (3/84, 5/84, 8/84, 11/84, and 3/85); (3) a Cochato River location near the clay cap area (2/84, 5/84, 8/84, 11/84, 3/85); and (4) a Cochato River location downstream of the confluence with the unnamed brook (5/83). The 5/83 unnamed brook sample contained 1100 ppb arsenic, 6 ppb trichloroethylene, and 8 ppb acenaphthene. The location between the clay cap and Cochato River contained arsenic levels ranging from 61-930 ppb, and infrequent detections of low level organic contamination. The Cochato river locations contained arsenic levels of 6-21 ppb. Organic contaminants were monitored on 8/84 and 3/85 at the Cochato River location nearer the clay cap. The contaminants detected included 31 ppb 2,4-dimethylphenol, 1 ppb 2-methylnaphthalene, 1 ppb acenaphthene, 0.10 ppb lindane, 0.32 ppb 4,4'-DDD, 2 ppb tetrachloroethylene, 2 ppb ethylbenzene, and 4 ppb xylenes.

4. Sediment

Sediment contamination was monitored during the course of several investigations. During the Phase I RI [43], eighteen samples (includes one soil boring sample comprised of sediments and obtained from near the unnamed brook) were monitored for HSL organic and inorganic constituents. One off-site and ten on-site locations were monitored. The on-site locations were situated in the unnamed brook (4 locations), in the tributary running between the clay cap and the Cochato River (one sample), and in the Cochato River (six locations). At six locations, samples were obtained at depths of 0-0.5 feet and 1.5-2.0 feet. At four locations only surface (0-0.5 feet) sediment samples were obtained.

During the Phase II investigation [42], seventeen samples from seventeen locations were monitored for HSL constituents and for herbicides. Each sample was a composite grab of the upper twelve inches of sediment. Six samples were obtained on-site. Three samples were from locations south of the clay cap (one Cochato River channel location and two west bank/southern wetland locations). Another three samples were from locations north of the clay cap (one location in the unnamed brook and two locations in the channel of the Cochato River).

Eighty-four samples from 44 locations were monitored for TCL inorganic and organic constituents, and for herbicides during the Cochato River Sediment Study [22]. Three depth increments were monitored: increment one, 0-6 inches; increment two, 12-18 inches; and increment three, 18-36 inches. Twenty-four samples were obtained from eight locations on-site (seven in the channel of the Cochato River and one in the western floodplain).

Ten on-site and six off-site sediment samples were monitored for 2,3,7,8-TCDD by the EPA's Emergency Response Team on July 24-25, 1985 [8,27] The on-site samples were obtained from the unnamed brook (4 samples) and the Cochato River (4 samples from the channel and 2 samples from the east bank). None of the on-site samples contained detectable levels of 2,3,7,8-TCDD.

A summation of the on-site sediment monitoring results is presented in Table C-1B. For the purpose of presentation, the site is split into four areas: (1) the on-site portion of the Cochato River from the southern wetlands south to the site fence; (2) the portion of the Cochato River along the clay cap; (3) the Cochato River from the confluence with the unnamed brook to the northern site boundary; and (4) the unnamed brook.

The first Cochato River sediment monitoring area extends from the southern site boundary along the southern wetlands to the location of the former southern site boundary (just south of the clay cap). Five monitoring locations are within this area and consist of nine samples from four channel locations and two samples from two west bank/southern wetland locations. Samples obtained from the Cochato River channel contained little or no contaminants of concern. One surface sample (0-6 inches) contained 175 ppb lindane, and another surface sample (0-12 inches) contained 14 ppb 4,4'-DDT. Arsenic was detected at 0.85-3.6 ppm. The two samples obtained from the southern wetland along the western bank of the Cochato River contained higher levels of the contaminants of concern, specifically: 76 ppb chlordane; 10 and 19 ppb 4,4'-DDE; 19 and 39 ppb 4,4'-DDD; 2,880 and 31,000 ppb PAHs (namely 380 and 31,000 ppb naphthalene); 95 ppb total xylenes; 160 ppb ethylbenzene; and 58 ppm arsenic. The wetland sample obtained from a location closer to the clay cap contained the higher levels of contamination.

The second Cochato River sediment monitoring location is located along the clay cap from the former southern site boundary to the confluence with the unnamed brook. Four Cochato River channel locations and two locations in the floodplain between the clay cap and the Cochato River were monitored for contaminants. Four surface samples (0-6 or 0-12 inch depth interval) and five subsurface samples (12-18, 18-24, or 18-36 inch intervals) were obtained from the channel locations. The maximum levels of the contaminants of concern detected in the surface samples are: 180 ppb 4,4'-DDD; 57,000 ppb PAHs (namely 36,000 ppb naphthalene and 21,000 ppb 2-methylnaphthalene); 13,000 ppb total xylenes; 21 ppb tetrachloroethylene; 3,700 ppb ethylbenzene; and 12 ppm arsenic. The subsurface samples

contained lower levels of naphthalene, 2-methylnaphthalene, total xylenes, ethylbenzene, and arsenic. One floodplain monitoring location was situated in the small stream which runs parallel to and eventually drains into the Cochato River. Sampling at this location consisted of one surface sample (0-6 inch interval) and one subsurface sample (18-24 inch interval). The contaminants detected in the surface sample consisted of 65 ppb lindane; 0.27 ppb 2,4,5-T; 0.08 ppb 2,4-D; 96,200 ppb PAHs (namely 87,880 ppb naphthalene and 8,320 ppb 2-methylnaphthalene); and 2.5 ppm arsenic. Lower levels of the PAHs and lindane were detected in the subsurface sample. The second floodplain monitoring location is situated between the Cochato River and the stream. Sampling at this location consisted of one surface sample (0-6 inch interval) and two subsurface samples (12-18 and 18-36 inch intervals). Contamination detected in the surface sample consisted of 58 ppb 4,4'-DDT; 780 ppb fluoranthene; 770 ppb other PAHs; and 6.2 ppm arsenic. The subsurface samples contained low levels of naphthalene and 2-methylnaphthalene.

The third on-site area is the unnamed brook. Monitoring of the brook entailed six samples from five locations, and occurred along the stretch of the brook from just west of the railroad tracks (and north of the location of the former laboratory building) to nearly the confluence with the Cochato River. Contamination detected in the five surface samples occurred sporadically. The maximum levels of contaminants are: 12,000 ppb dieldrin; 76,000 ppb chlordane; 5,600 ppb 4,4'-DDT; 56,000 4,4'-DDE; 190,000 ppb 4,4'-DDD; 17,000 ppb fluoranthene; 3,300 ppb benzo(a)pyrene; 238,900 ppb other PAHs (not naphthalene or 2-methylnaphthalene); 6,400 ppb naphthalene (in one sample); 90 ppb total xylenes; 110 ppb ethylbenzene; and 1,290 ppm arsenic. Most of the contamination was detected in three of the five surface samples. The subsurface sample contained 44,600 ppb chlordane; 183,000 ppb 4,4'-DDT; 8,180 ppb 4,4'-DDE; 110,000 ppb 4,4'-DDD; and 40 ppm arsenic.

The fourth on-site location is the portion of the Cochato River extending from the confluence with the unnamed brook north to the Mear Road culvert. All seven monitoring locations are situated within the channel of the river. Seven surface samples (0-6 or 0-12 inch intervals) and seven subsurface samples (12-18, 18-24, or 18-36 inch intervals) were monitored for contaminants. Insecticides were the predominant contaminants detected. The maximum levels of the contaminants of concern detected in the surface samples are: 140 ppb dieldrin; 4,200 ppb chlordane; 1,600 ppb 4,4'-DDT; 420 ppb 4,4'-DDE; 8,400 ppb 4,4'-DDD; 27 ppb lindane (only one sample); 1,100 ppb fluoranthene; 430 ppb benzo(a)pyrene; 6,690 ppb other PAHs (one sample contained

330 ppb naphthalene); 15 ppb total xylenes; 63 ppb trichloroethylene; and 406 ppm arsenic. The subsurface samples contained less contamination. The maximum levels of contamination in the subsurface samples are: 890 ppb chlordane; 300 ppb 4,4'-DDT; 120 ppb 4,4'-DDE; 1,000 ppb 4,4'-DDD; 460 ppb PAHs; and 59 ppm arsenic.

5. Fish

Two independent monitoring studies have been conducted to assess the impact of Baird and McGuire site-related contamination of fish in the Cochato River and related waters. The on-site fish monitoring data for the contaminants of concern are summarized in Table C-1B. The first study was performed by the DEQE (now, DEP) Division of Water Pollution Control in order to determine the presence of 2,3,7,8-TCDD in edible fish fillets [66,73]. Fish were harvested by electrofishing or gillnetting during July of 1985. There were five sampling locations of which one was on-site at the downstream end of the site near Mear Street. No fish were harvested by electrofishing at the Mear Street sampling location; therefore, there are no on-site TCDD data for fish. For each of the remaining locations, the left fillets (edible portion from the left half of the fish) from 6 to 10 fish were composited per species.

The second study is presented in the Phase II RI report [42]. Eight fish samples from five locations obtained in December of 1985 were monitored for the presence of insecticides and PAHs. Two of the eight samples were composites of 2 to 3 fish of a given species due to the small size of the fish. Whether the portion of the fish analyzed was the edible fillet is unknown. Three of the sampling locations were within the site boundaries, and consisted of 6 samples including the two composites. The first sampling station is located in the Cochato River at the upstream end of the site, that is, just downstream of the southern portion of the site security fence. Three small pumpkinseeds (Lepomis gibbosus) were composited and were found to contain breakdown products of 4,4'-DDT, specifically, 4,4'-DDE (0.062 ppm) and 4,4'-DDD (0.093 ppm). The second station is located in the Cochato River adjacent to the clay capped area. Two samples were obtained, and consisted of a composite of two golden shiners (Notemigonous crysoleucas) and a sample of an individual chain pickerel (Esox niger). The golden shiner sample contained 4,4'-DDE (0.42 ppm), 4,4'-DDD (1.30 ppm), and chlordane (1.10 ppm). The chain pickerel sample contained 4,4'-DDE (0.58 ppm), 4,4'-DDD (1.70 ppm), chlordane (1.20 ppm), and PAHs [3.77 ppm (2-methylnaphthalene - 1.20 ppm, and naphthalene - 2.3 ppm)]. The third sampling station is located in the Cochato River between the mouth of the unnamed brook and the Mear

Road culverts, and consisted of three samples (two individual golden shiners and one pumpkinseed). The two golden shiner samples contained 4,4'-DDE (0.40 and 0.70 ppm), 4,4'-DDD (1.40 and 3.70 ppm), chlordane (1.20 and 2.00 ppm), and PAHs [0.85 ppm (2-methylnaphthalene - 0.19 ppm, and naphthalene - 0.66 ppm) and 0.80 ppm (naphthalene - 0.80 ppm)]. The pumpkinseed sample contained 4,4'-DDT (0.37 ppm), 4,4'-DDE (1.00 ppm), 4,4'-DDD (4.70 ppm), and PAHs [7.09 ppm (2-methylnaphthalene - 1.9 ppm, and naphthalene - 3.0 ppm)]. Naphthalene and 2-methylnaphthalene levels are given because these two compounds comprised the greatest proportion of PAHs detected.

6. Ambient Air

The results of on-site ambient air monitoring were reported in both the Phase I and Phase II RIs [42,43], and are summarized in Tables C-1A and C-1B for the contaminants of concern. The Phase I RI summarizes the results of two field screening events. First, in June 1983, an air monitoring screening by EPA detected the presence of phenols in the ambient air of several areas of the site. Second, in October 1984 as part of the Phase I RI, field monitoring was conducted for total detectable volatile organic compounds using an HNu photoionization detector. Six on-site locations were monitored, specifically, three stations near the BMCCI buildings, one station between the clay cap and the Cochato River, one station east of the storage building in the woods, and one station near the beginning of the trail leading to the municipal wells. Nothing was discerned above the detection limit of 1 ppm for total detectable volatile organic compounds.

The Phase II RI presents the results of two ambient air monitoring programs. The first study was conducted on August 28-29, 1985, and entailed the collection of 24-hour samples in five locations. Four of the five locations are on-site. The samples were monitored for the presence of 2,4,7,8-TCDD. No 2,3,7,8-TCDD was detected. See the section on quality assurance and quality control for a discussion on the detection limit.

The second study was conducted to monitor for ambient air contamination during a cool windy period (April 17 and April 18, 1986). Surface soils were exposed in contaminated areas. The average hourly wind speed during the period of monitoring ranged from 5.6 miles per hour to 11.5 miles per hour, and gusts ranged to 15 and 24 miles per hour for each of the two days. The wind direction was to the southwest. Monitoring stations included the six locations utilized during the Phase I study plus three new on-site locations. The three new locations are (1) at the recharge galley of

the on-site ground water recirculation system, (2) near the main entrance to the site, and (3) across the river at the southwest corner of the New Can Company parking lot.

The contaminants monitored for were volatile organic compounds at 7 of the 9 stations, semi-volatile organic compounds/insecticides at 7 of the 9 stations, and arsenic at all 9 stations. Arsenic was not detected at any location (detection limit was 0.08 micrograms per meter cubed [ug/m^3]). No insecticides or polychlorinated biphenyls (PCBs) were detected with detection limits of 0.003 to 0.07 ug/m^3 for a given compound. The semi-volatile organic compounds were detected in only one of the seven stations, that is, at the station near the recharge galley. Trace levels of naphthalene (0.07 ug/m^3) and 2-methylnaphthalene (0.04 ug/m^3) were detected. No volatile organic compound data were available because the data were unvalidated and the blank was contaminated.

7. Private/Municipal Water Supplies

There are no on-site private or municipal water supply sources (ground water or surface water).

B. Off-Site Contamination

1. Ground Water

The ground water monitoring studies are described in the section in on-site ground water contamination. Off-site ground water monitoring was conducted during the Phase I and II RIs for HSL inorganic and organic constituents [42,43]. During the Phase I RI, one well was monitored from each of two off-site monitoring well locations near the South Street wells #1 and #2. Monitoring Well 907B is located immediately east of South Street well #1 and is screened at 15-45 feet below ground level. Contaminants detected include 4,4'-DDT (0.032 ppb), 4,4'-DDE (0.017 ppb), and lindane (0.15 ppb) were detected. Monitoring Well 905A is located immediately south of South Street well #2 and is screened at 51.5-56.5 feet (to refusal). No contaminants of concern were detected.

During the Phase II RI, ten off-site wells in five monitoring well locations were monitored. These wells were located in the South Street Wellfield (south of the site) and in the Cochato Industrial Park (across the Cochato River from the site). Monitoring Well 905B is located immediately south of South Street well #2 and is screened at 13-43 feet below ground surface. This well contained 0.45 ppb 2,4-D. No contaminants of concern were detected in the three

remaining South Street wellfield overburden monitoring wells located in three areas of the wellfield. Monitoring Well 907B is located immediately east of South Street well #1 and is screened at 15-45 feet. Monitoring Wells 916 and 916B are located in the sand pit south of the wellfield and are screened at 20-40 and 6-15 feet, respectively.

The six off-site Cochato Industrial Park monitoring wells are located in two clusters. One well is installed in bedrock, and the remaining wells are installed in overburden. Monitoring Well Cluster 917 is located south of the New Can Company Inc. building. The one shallow bedrock well contained 20 ppb of PAHs, and one of the two overburden wells contained 29 ppb arsenic. The second cluster is located north of the New Can Company Inc. building and south of Mear Road. The two deepest overburden wells contained tetrachloroethylene (5-8.3 ppb).

A summary of the off-site ground water contamination is presented in Table C-2B. Additional off-site ground water information is presented in the section regarding off-site private/municipal water supplies.

2. Soil

Off-site soil monitoring was conducted during the Phase II RI [42]. Details on the soil monitoring program are presented in the section in on-site soil contamination. Soil monitoring for 2,3,7,8-TCDD was conducted by EPA's Emergency Response Team in the yards of five residences located across South Street from the site (west) [8,27]. No detectable levels of 2,3,7,8-TCDD were detected. Off-site Phase II monitoring areas are located in: (1) the South Street wellfield, (2) the field east of the South Street wellfield, (3) the sand pit west of the South Street wellfield, (4) the wetland south of the South Street wellfield, and (5) the wetland north of the tank farm. A brief description of the off-site soil contamination follows, and is summarized in Table C-2B.

The South Street wellfield contained two soil monitoring locations, one west of town well #3 and one south of town well #1. In the 10-12 foot composite from the location near town well #3, 250 ppb of 2,4-D was detected. Little or no contaminants were detected in the remaining seven subsurface samples obtained at depths to 22 feet. The two near surface samples (0-2 feet) contained relatively low levels of DDT and related compounds (12-31 ppb 4,4'-DDT; 51 ppb 4,4'-DDE; and 30 ppb 4,4'-DDD). One sample contained 1870 ppb PAHs.

Two surface soil (0-1 and 0-0.5 feet) monitoring locations are located in the wetland to the south of the South Street

wellfield. One sample contained 700 ppb 4,4'-DDT, 440 ppb 4,4'-DDE, and 850 ppb 4,4'-DDD. Both samples contained fluoranthene (470-760 ppb) and other PAHs (1,002-2,850 ppb). One surface soil sample was obtained from the sand pit west of the wellfield, and it was found to contain 31 ppb 4,4'-DDT.

The field to the east of the wellfield contained three soil monitoring locations. Three near surface soil samples (0-2 feet) and eleven subsurface soil samples (obtained to a depth of 22 feet) were monitored for contaminants. Two of the surface soil samples contained low levels of insecticides, specifically 4,4'-DDT (3.1-4.9 ppb), 4,4'-DDD (16-30 ppb), and chlordane (12 ppb). Higher levels of insecticides were detected in the eight subsurface samples obtained at depths ranging from ten to twenty-two feet (5.2-480 ppb 4,4'-DDT; 11-430 ppb 4,4'-DDE; 4.8-2,200 ppb 4,4'-DDD; 10-1,800 ppb chlordane; and 2.3-2.4 ppb dieldrin). One subsurface sample obtained at a depth of 10-12 feet contained 2,860 ppb PAHs (of which 2,100 ppb was due to the presence of 2-methylnaphthalene).

The final off-site soil monitoring area was north of the tank farm. Two monitoring locations consisted of two surface soil samples (0-2 feet) and five subsurface soil samples obtained to a depth of 17 feet. A third monitoring location consisted of one surface soil sample (0-1 foot interval). Compounds of concern in the surface soil samples consisted of 4,4'-DDT (10-350 ppb), 4,4'-DDE (3.4-110 ppb), 4,4'-DDD (9.2-27 ppb), dieldrin (3.8 ppb), chlordane (89 ppb), fluoranthene (550-590 ppb), benzo(a)pyrene (370 ppb), other PAHs (1143-3460 ppb), and lead (95 ppb). The subsurface soil samples contained lesser amounts of the same chemicals: 4,4'-DDT (3.9-130 ppb), 4,4'-DDE (5-13 ppb), 4,4'-DDD (13-99 ppb), dieldrin (4.1-15 ppb), chlordane (23-75 ppb), 2,4,5-T (260 ppb), and PAHs (180-970 ppb).

3. Surface Water

Several surface water investigations examined off-site surface water quality, and the available pertinent data are summarized in Table C-2A. The surface water studies presented in the Phase I RI [42] and the ground water recirculation system report [46] are described in more detail in the section in on-site surface water contamination. The three Phase I off-site Cochato River monitoring stations were located: (1) immediately upstream of the site (HSL organic and inorganic compounds), (2) immediately downstream of the site just across Mear Road (total arsenic levels), and (3) downstream of the site but prior to Union Street (total arsenic levels). The two downstream stations were monitored on 6/26/84 and contained

no detectable levels of arsenic (<10 ppb). The upstream station was monitored on 6/26 and 10/4/84 and was found to contain arsenic (16 and 9.5 ppb, respectively) and lead (6.2 and 4.1 ppb, respectively), but no organic contaminants of concern. The one sampling location for the ground water recirculation system study is located downstream of the site, and was monitored for arsenic on 5/83, 9/83, and 2/84. The arsenic levels detected ranged from <5 ppb to 130 ppb.

The DEQE investigation included heavy metal monitoring of the Cochato River at four locations downstream of the site and at six locations on tributaries that drain into the Cochato River between the downstream end of the site and the Richardi Reservoir [75]. Arsenic levels were determined six times during the period 4/27/84 to 3/20/85. Arsenic levels were most prevalent at the Union Street monitoring station (5 detects/6 samples, range of 2-24 ppb, and mean of 10 ppb). Other Cochato River monitoring locations for arsenic were (1) downstream of Mary Lee Brook (0/6), (2) downstream of the Tumbling Brook (4/6, 1-2 ppb, mean = 1.8 ppb), and (3) near the Richardi Reservoir (3/6, 1-15 ppb, mean = 6.0 ppb). For monitoring stations located on the tributaries, arsenic was detected in ten of forty samples with a range of 1-29 ppb and a mean of 7.1 ppb.

The third investigation with off-site surface water samples was the 2,3,7,8-TCDD investigation conducted by EPA's Emergency Response Team on 7/24-25/85 [8,27]. The two off-site locations were in Lake Holbrook and the Richardi Reservoir. No 2,3,7,8-TCDD was detected in either sample (detection limit was not given).

The fourth investigation with off-site Cochato River surface water monitoring was the Cochato River Sediment Study [22]. Seven off-site monitoring stations were sampled in April, 1988. Unfiltered samples were monitored for TCL organic compounds and metals, and filtered samples were monitored for TCL semi-volatile organic compounds, insecticides and metals. The seven stations were located just upstream of the site (SW1), just downstream of the site near Mear Road (SW2), between Union Street and Sylvan Lake (SW3), just upstream of the Ice Pond (SW4), just upstream of Tumbling Brook (SW5), near the Richardi Reservoir (SW6), and upstream of Martin Brook (SW7).

Naphthalene was detected in unfiltered samples from stations SW2 (5 ppb) and SW3 (3 ppb), and in a filtered sample from SW2 (4 ppb) at levels below the Contract Required Detection Limit (CRDL) for the Contract Laboratory Program (CLP) of 10 ppb. Arsenic was not detected in any sample (detection limit of 10 ppb).

4. Sediment

The investigations entailing sediment monitoring are described in the section in on-site sediment contamination. During the Phase I RI [42], two samples (0-6 and 18-24 inch intervals) from one off-site location (in the Cochato River between Mear Road and Union Street) were monitored for contamination. During the Phase II investigation [42], eleven samples obtained from the 0-12 inch interval at eleven locations were monitored. Four upstream locations [(1) Cochato River immediately south of the site fence; (2) tributary C2 which drains into the Cochato River; (3) Lake Holbrook; and (4) wetland east of the Cochato River] and seven downstream locations [(1) one sample in the Cochato River between Union Street and Sylvan Lake; (2) one sample in Sylvan Lake; (3) two samples in the Ice Pond; (4) one sample from the eastern bank of the Cochato River after the confluence with Mary Lee Brook; and (5) two samples in the Richardi Reservoir] were monitored.

During the Cochato River Sediment Study [22], sixty samples from thirty-six off-site locations were monitored. Sampling depths are given in the section in on-site sediment contamination. Monitoring stations were located: (1) upstream of the site (in Lake Holbrook, in the Cochato River near the southern site boundary, and in a tributary southeast of the site); (2) in downstream tributaries (Mary Lee, Glovers, Cranberry, Martin, and Tumbling Brooks); (3) along the Cochato River from the site boundaries to the Richardi Reservoir; and (4) in associated downstream ponds and lakes (Sylvan Lake, Ice Pond, and the small pond which was pumped to the Richardi Reservoir in the past). Some of these samples were obtained from the banks and wetlands that are located within the floodplain of the Cochato River and associated waters.

Six off-site sediment samples were monitored for 2,3,7,8-TCDD by the EPA's Emergency Response Team on July 24-25, 1985 [8,27]. These samples were obtained from: (1) the Cochato River just north of the Mear Road culvert and again near Mill Street; (2) Sylvan Lake; (3) Lake Holbrook; and (4) twice near the Richardi Reservoir sluice way. No 2,3,7,8-TCDD was detected in any of the samples.

For the ease of presentation, the off-site sediment monitoring data is divided in nine groups based on location: (1) upstream; (2) downstream tributaries; (3) the Cochato River from the northern site boundary (Mear Road) to Sylvan Lake; (4) Sylvan Lake; (5) the Cochato River from Sylvan Lake to the Ice Pond; (6) Ice Pond; (7) the Cochato River from the Ice Pond to the Glovers Brook confluence; (8) from the Glovers Brook confluence to the Richardi Reservoir; and

(9) the Richardi Reservoir. The available data are summarized in Table C-2A.

Group 1 consists of the available upstream (mostly south) sediment monitoring data. Nine samples from eight locations were monitored. Three samples contained insecticides of concern. One Lake Holbrook sample contained 300 ppb chlordane, 2,500 ppb 4,4'-DDT, 23 ppb 4,4'-DDE, and 210 ppb 4,4'-DDD. The sample obtained from the wetland east of the Cochato River contained lower levels of insecticides. The sample obtained from the Cochato River about 210 feet south of the site boundary contained 13,000 ppb 4,4'-DDE and 75,000 ppb 4,4'-DDD. The remaining samples (three from Lake Holbrook, one from tributary C2, one from the tributary to the east, and one from near the site boundary in the Cochato River) contained no insecticides of concern. The maximum concentration of the prevalent contaminants of concern are 740 ppb fluoranthene and 1,940 ppb other PAHs.

Group 2 consists of monitoring data from the downstream tributaries, specifically, Mary Lee Brook, Glovers Brook, Tumbling Brook, Martin Brook, and Cranberry Brook. Seven samples from seven locations were monitored for contaminants. One sample from Martin Brook contained 58 ppb 4,4'-DDD. No other sample contained detectable levels of the insecticides of concern. The maximum level of the prevalent contaminants are: 5,600 ppb fluoranthene; 1,700 ppb benzo(a)pyrene (one sample only); and 16,520 ppb other PAHs.

Group 3 data were from Cochato River samples located between the Mear Road culvert and Sylvan Lake. The twelve samples from five locations (one floodplain and four channel locations) consisted of five surface sediment samples (0-6 or 0-12 inch depth interval) and seven subsurface sediment samples (12-18, 18-36 or 18-24 inch depth interval). The floodplain monitoring consisted of two samples from one location west of the Cochato River and just north of Mear Road. The surface sample contained 340 ppb chlordane, 740 ppb 4,4'-DDT, 500 ppb 4,4'-DDD, 9,100 ppb fluoranthene, 4,400 ppb benzo(a)pyrene, 52,720 ppb other PAHs (including 1,200 ppb naphthalene and 920 ppb 2-methylnaphthalene), and 17 ppm arsenic. The subsurface sample (12-18 inch interval) contained lower amounts of contamination. The maximum levels of contamination in the surface sediment samples from the channel are: 1,210 ppb chlordane; 6,000 ppb 4,4'-DDD; 7,200 ppb fluoranthene; 3,400 ppb benzo(a)pyrene; 36,000 ppb other PAHs (including 810 ppb naphthalene); and 65 ppm arsenic. Generally, the maximum levels of contamination in the subsurface samples from the channel were similar to those of the surface samples.

Group 4 data consist of eight samples from four locations in and near Sylvan Lake. Two locations (three samples) were near the inlet leading to the Cochato River. One location is at the center of the lake, and one location is at the northeastern shore of the lake. The maximum level of contamination in the samples from near the inlet are: 120 ppb chlordane; 760 ppb 4,4'-DDT; 380 ppb 4,4'-DDE; 2,000 ppb 4,4'-DDD; 2,800 ppb fluoranthene; 330 ppb benzo(a)pyrene; 7,400 ppb other PAHs; and 53.5 ppm arsenic. There are no insecticide data available for the samples from the center of the lake. Low levels of trichloroethylene (15 ppb) and vinyl chloride (22 ppb) were detected. No other contaminants of concern were detected. The surface sample from the shore of the lake contained 41 ppb 4,4'-DDT; 170 ppb 4,4'-DDE; 150 ppb 4,4'-DDD; 1,400 ppb fluoranthene; and 5.2 ppm arsenic.

The group 5 location extends along the Cochato River from Sylvan Lake to the Ice Pond. No sediment samples were available for this area.

Group 6 data were obtained from the eight samples from five locations in and near the Ice Pond. Two locations (one subsurface and two surface samples) are at the southern end of the pond. Another two locations (two surface and two subsurface samples) are at the northern end of the pond. One surface sample was obtained from the floodplain along the western shore of the Ice Pond. The surface samples from the upstream and downstream locations contained similar levels of contamination. The maximum levels of contamination detected in the surface samples are: 4,800 ppb chlordane; 170 ppb 4,4'-DDT; 1,100 ppb 4,4'-DDE; 5,000 ppb 4,4'-DDD; 8,800 ppb fluoranthene; 2,900 ppb benzo(a)-pyrene; 18,500 ppb other PAHs; 24 ppb trichloroethylene; and 334 ppm arsenic. The floodplain surface sample contained 230 ppb chlordane, 240 ppb 4,4'-DDD, 400 ppb fluoranthene, 890 ppb other PAHs, and 133 ppm arsenic.

Group 7 entailed the length of the Cochato River from the Ice Pond to the confluence with Glovers Brook. Two monitoring locations (two surface and two subsurface samples) were situated in the river channel, and three locations (three surface and two subsurface samples) were along the banks/floodplain of the river. The surface and subsurface channel samples from one location contained similar amounts of insecticides: 23-53 ppb dieldrin; 370-570 ppb chlordane; 230-330 ppb 4,4'-DDE; and 1,000-1,400 ppb 4,4'-DDD. There were no monitoring data available for the remaining insecticides of concern. The surface sample also contained 910 ppb fluoranthene, 1,590 ppb other PAHs, and 80.9 ppm arsenic. There were virtually no monitoring data available for the other channel location. The surface

and subsurface bank/floodplain samples contained similar amounts of insecticides as the channel samples. The maximum amount of other contaminants detected are: 530 ppb fluoranthene; 340 ppb benzo(a)pyrene; 2,070 ppb other PAHs; and 58.5 ppm arsenic. Naphthalene (160 ppb) and 2-methylnaphthalene (150 ppb) were detected in one surface sediment sample.

The group 8 location is comprised of the portion of the Cochato River located between the confluence with Glovers Brook and the Richardi Reservoir. This group is separated into three subgroups: (1) from the confluence with Glovers Brook to the confluence with Tumbling Brook; (2) from the confluence with Tumbling Brook to the confluence with Martin Brook; and (3) from the confluence with Martin Brook to the Richardi Reservoir. For the first subgroup, there are three surface and two subsurface samples from three channel locations and one surface sample from the west bank. The maximum levels of the contaminants of concern detected in the channel samples are 200 ppb dieldrin, 330 ppb 4,4'-DDD, 6,300 ppb fluoranthene, 3,000 ppb benzo(a)pyrene, 38,100 ppb other PAHs, and 40 ppm arsenic. The sample from the bank contained 1,040 ppb naphthalene.

For the second subgroup, eight samples were obtained from five channel locations and one sample was obtained from the western floodplain. The maximum levels of contaminants of concern detected in the surface samples from the channel are: 500 ppb 4,4'-DDD; 810 ppb fluoranthene; 2,830 ppb other PAHs (including 640 ppb naphthalene); and 25 ppm arsenic. The subsurface samples contained less contamination. The floodplain sample contained 160 ppb 4,4'-DDD; 1,100 ppb PAHs; and 13 ppm arsenic.

For the third subgroup, two samples were obtained from one location in the pond from which at one time water was pumped to the Richardi Reservoir. Dieldrin (10 ppb) was detected in the subsurface sample, but not the surface sample. No other insecticide data were available.

The group 9 location is the Richardi Reservoir. Two samples from two locations were obtained when the reservoir was drained for routine maintenance and inspection. The maximum contamination detected in the two samples consisted of 330 ppb fluoranthene and 660 ppb other PAHs.

5. Fish

Two fish monitoring studies have been conducted in relation to the Baird and McGuire site. The details of the two studies are presented in the section in on-site fish contamination. The off-site fish monitoring data for the

contaminants of concern are summarized in Table C-2A. The first study conducted by DEQE in July of 1985 monitored for the presence of 2,3,7,8-TCDD in fish [66]. Four off-site sampling stations were located along the Cochato River and associated waters. The first station is located 700 meters upstream from the site in Lake Holbrook which is separated from the Cochato River by a water spillway. The yellow perch (Perca flavescens) composited sample contained 1.0 parts per trillion (ppt) of 2,3,7,8-TCDD. The second station is located 800 meters downstream from the site in Sylvan Lake. The brown bullhead (Ictalurus nebulosus) composite contained 3.0 ppt of 2,3,7,8-TCDD. The third sampling station is located in the Cochato River about 1400 meters downstream of the site and near Mill Street in Randolph. The golden shiner composite contained 4.5 ppt of 2,3,7,8-TCDD. The fourth monitoring station is located in Hollingsworth Pond in Braintree about 6300 meters from the site. The pumpkinseed composite contained no detectable 2,3,7,8-TCDD (detection limit was 0.5 ppt).

The second study was conducted as part of the Phase II RI in December of 1985 [43]. Fish samples were monitored for insecticides and PAHs. The one off-site monitoring station is located in the ice pond just downstream from Sylvan Lake. Two samples consisted of one pumpkinseed individual and one redfin pickerel (Esox americanus) individual. The pumpkinseed sample contained 4,4'-DDT (0.19 ppm), 4,4'-DDE (1.20 ppm), 4,4'-DDD (2.70 ppm), and PAHs [1.76 ppm (0.18 ppm 2-methylnaphthalene and 0.38 ppm naphthalene)]. The redfin pickerel sample contained PAHs [0.33 ppm (no 2-methylnaphthalene or naphthalene)].

6. Ambient Air

Only one off-site ambient air sample was monitored for contaminants. The sample was taken as part of the Phase II 2,3,7,8-TCDD ambient air investigation [42]. The sample was obtained behind the Holbrook Fire Station for a background sample, and contained no detectable 2,3,7,8-TCDD.

7. Private/Municipal Water Supplies

a. Private Water Supplies

Water from two private water supplies that exist in the general vicinity of the Baird and McGuire site have been monitored for contamination. The existence of a residential water supply well was presented in the Phase I RI [43]. This well was identified during a review of Holbrook Town records, and is located about 1,900 feet southeast of the site on English Road. The well was monitored on June 18, 1984 for purgeable

organic compounds, and was found to contain 1,1-dichloroethane at its detection limit (1 ppb).

An industrial water supply well was discovered in the fall of 1985 when a well drilling rig was observed at Accurate Metal Finishing located on South Street in Randolph, MA [42]. This facility is located about 500 feet northwest of the location of the BMCCI tank farm. This well was installed 39 feet into the overburden and is normally run at 60 to 70 gallons per minute (gpm), although its rated capacity is 150 gpm. Monitoring of the well on January 16, 1986 resulted in the detection of trichloroethylene (220 ppb), trans-1,2-DCE (78 ppb), and acetone (23 ppb). Two abandoned industrial water supply wells located at this facility were not monitored.

b. Municipal Water Supplies

Randolph and Holbrook have a joint water board responsible for supplying potable water to both townships. The only current water source is a surface water supply called the Great Pond/Upper Reservoir [59,93,96]. Monitoring of finished waters for volatile organic compounds is performed on a quarterly basis and reported to the DEP. During the year 1988, two of the four finished water samples contained chloroform (1.5 and 6.0 ppb) [9-12]. This water supply is chlorinated [59,93,96]; hence, the presence of chloroform, a trihalomethane, is a result of chlorination. No other volatile organic compounds were detected in the four finished and one raw water samples.

The Town of Braintree shares the same water source as Randolph/Holbrook, that is, the Great Pond/Upper Reservoir [6,7]. Braintree has a separate water intake and treatment plant. Monitoring of finished waters for volatile organic compounds is performed on a quarterly basis. Monitoring data were available for the first three quarters of 1988 [13-15]. Chloroform was detected in all three samples at 4, 26 and 14 ppb. Bromodichloromethane was detected in the third quarter sample at 11 ppb. No other volatile organic compounds were detected. No raw water monitoring data were available. This water supply is chlorinated; hence, the presence of the trihalomethanes is probably due to chlorination.

The South Street and Donna Road wells are located in Holbrook, and were monitored for volatile organic contaminants by the DEQE during the period 1980 to 1981 [45,71]. The South Street wells #'s 1-3 and the Donna

Road wellfield were monitored in March and again in May or June of 1980.

South Street Well #1 was also monitored on November 12, 1980 by an analytical laboratory called Oliveira [45]. South Street Well #1 was remonitored by DEQE on February 11, April 15 and April 23, 1981 [71].

The Donna Road Wellfield contained no detectable volatile organic compounds during either monitoring event. The concentrations of compounds detected during the South Street wellfield monitoring events are presented in Table II. In addition to the compounds listed above, water samples from South Street well #1 contained methylene chloride (1.1-1.4 ppb), 1,1-dichloroethane (1.6 ppb), 1,2-dichloroethane (0.6 ppb), and carbon tetrachloride (15 ppb).

Table II
Contaminants Detected in South Street Wells

South St. Well#	Concentration (ppb) One						Two		Three	
Compound/Date	3/80	5/80	11/80	2/81	4/81	4/81	3/80	5/80	3/80	5/80
1,1-DCA*	7.6	6.8	4.0		14.8	15.0	7.3	12.8	24.0	20
trans-1,2-DCE	0.9	2.0	1.7		3.8	4.1	0.9	3.0	20.3	73
chloroform			2.5	5.2	0.5	0.5	2.1		1.6	
1,1,1-TCA	0.2	1.3	1.2		1.9	2.0	2.6	3.5	8.1	15
TCE		1.0	3.6		0.6	1.4		1.0	1.4	17
benzene							8.9			1.7
TETRA		1.2	0.9		2.2	1.4	0.5	1.2	0.6	3.8

* 1,1-DCA, 1,1-dichloroethane; trans-1,2-DCE, trans-1,2-dichloroethylene; 1,1,1-TCA, 1,1,1-trichloroethane; TCE, trichloroethylene; TETRA, tetrachloroethylene

Additional historical monitoring data for the South Street wells are presented in the Baird and McGuire Site Assessment report [45]. Phenols were monitored by the DEQE on 8/70 and by the DPH six times during the period 11/3/58-11/16/60. The levels of phenols detected in the South Street well #3 were: 11/3/58, none detected; 11/19/58, 0.055 ppm; 5/15/59, 0.20 ppm; 5/19/59, 0.32 ppm; 9/6/60, 0.80 ppm; 11/16/60, 0.30 ppm; and 8/70, 0.204 ppm. South Street well #1 was monitored on 8/70, and was found to contain 0.80 ppm phenols.

C. Quality Assurance and Quality Control

The investigations summarized in the previous two sections regarding environmental contamination originating from the Baird and McGuire site are many, and each investigation has its own quality assurance and quality control (QA/QC) experience. For each investigation, the QA/QC experience will be briefly described in order to assess the level of confidence in the data for the purpose of the Public Health Assessment. Investigations have been conducted by or on behalf of the EPA and DEQE as part of the remediation effort, and by consultants on behalf of the three townships potentially impacted by the site as part of the routine examination of municipal water supplies.

Virtually all the Phase I RI data sets (soil, ground water, surface water, and sediment) generated through the CLP were validated by EPA/NUS. The ambient indoor data set was discounted because it did not meet the EPA's acceptance criteria. The available indoor air data consisted of field measurements of total detectable volatile hydrocarbons by HNu photoionization detector with a detection limit of about 1 ppm.

Most of the samples were monitored through the CLP during the Phase II RI. The samples obtained from seepage meters, piezometers, and surface water were monitored for chlorinated and aromatic volatile compounds at a DEQE certified laboratory. These samples were obtained for quick response and were not validated. The remaining samples were monitored through the CLP, but only about 80% of the data were validated at the time the report was released. The majority of the samples were soil samples and most of these samples were validated. However, difficulty was encountered during analysis of the data for some of the soil samples because, although the data are presented in the appendix of the document, no description of the soil sample location or interpretation of the data are given. Organic compound data generated from the ground water samples were not validated. For ground water, fifty per cent of the inorganic data were validated. Seven of the eight ground water samples with detectable levels of lead were rejected. Sediment data were mostly not validated. Fish and air monitoring data were not validated. Select samples for air, ground water, soil, and sediment were monitored for 2,3,7,8-TCDD. Whether the data from

these samples were validated through the CLP is unclear; therefore, the validity of the dioxin data is of concern because great difficulty exists in analyzing dioxins at low levels and 2,3,7,8-TCDD is very toxic. The detection limit for the 2,3,7,8-TCDD monitoring of air samples was reported in the text of the Phase II RI to be 0.0028 parts per thousand and in the appendix to be 0.0028 parts per trillion. This discrepancy represents a nine orders of magnitude difference in detection limit.

The data for the Cochato River Sediment Study were validated through the CLP and REM III program. For many of the sediment samples, the actual detection limits for organic compound data are above the CLP's CRDL. For some samples and organic compounds, the actual detection limit is 150 to 230-fold higher than the CRDL. Of particular consideration is the pesticide data set. Virtually all of the insecticide detection limits are above the CRDL. Data values below the actual detection limit were reported as below detection limits in the summary tables with the CRDL reported. For example, sample SD120-1 was diluted 25-fold prior to analysis for insecticides. In the raw data set the following insecticides were detected: 1,100 ppb 4,4'-DDE (actual detection limit is 2,400 ppb and the CRDL is 16 ppb); 2,200 ppb 4,4'-DDD (actual detection limit is 2,400 ppb and the CRDL is 16 ppb); 670 ppb alpha-chlordane and 680 ppb gamma-chlordane (actual detection limit for each isomer of chlordane is 12,000 ppb and the CRDL for each isomer is 80 ppb). Although sample SD120-1 represents an extreme example, data for other samples indicate a substantial discrepancy between actual detection limits and CRDLs. Other insecticide data for the sediment samples were rejected during the validation process.

For insecticides, the actual detection limits for six of the nine ground water samples were three to ten-fold higher than the CRDL due to dilution of the samples prior to monitoring. Virtually all the lead data were rejected for the surface water and ground water samples during data validation.

The GZA's Site Assessment report presented the South Street Wells' drinking water monitoring data that was generated by other investigators/laboratories during the years 1958-1981. No QA/QC information was presented in this document for these data. In addition, no QA/QC information is available for the EPA ERT investigation for 2,3,7,8-TCDD or for the DEQE "Interim Report on Water Quality of the Cochato River and Its Tributaries."

The available DEQE report on the fisheries investigation to screen for 2,3,7,8-TCDD did not supply QA/QC information; however, it is known that the per cent recovery of 2,3,7,8-TCDD from the fish samples varied from sample to sample. The fish were composited according to species and monitoring station, and the species collected varied from station to station. For these

reasons, this data set cannot be used to conclusively define the 2,3,7,8-TCDD contamination of fish in the Cochato River, but was considered as a surrogate because of the lack of more conclusive data.

The DEQE's report on the "Installation and Monitoring of Interim Groundwater Containment System, Baird and McGuire Site" provided screening data on ground water quality and was not considered in this Public Health Assessment, except to define the effect of the ground water recirculation system on the local ground water flow pattern and the disbursement of site-related contaminants as determined in the DEQE report. This report also provided surface water monitoring data for the period 1983-1985, during which the recirculation system was initiated (early 1984). No QA/QC information was provided.

As for the Site Assessment report, no QA/QC information is available for the other reports which present monitoring results by various laboratories of contaminants in the municipal water supplies. At least some of these data originated from laboratories having DEQE certification. Whether the DEQE certification process has QA/QC requirements comparable to the EPA/NUS data validation process is unknown.

In preparing this Public Health Assessment on behalf of ATSDR, the MDPH relies on the information provided in the referenced documents and assumes that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analysis and conclusions drawn for this Public Health Assessment is determined by the availability and reliability of the referenced information.

D. Physical and Other Hazards

The presence of physical and other hazards was investigated during the July 11, 1989, Site Visit. The site is well maintained and clean. Most on-site buildings have been demolished. Four buildings remain on-site:

(1) the storage building, which contains dioxin-containing demolition debris, is well secured and alarmed to a security firm for smoke, heat and intrusion;

(2) the office building is bolted shut and is inaccessible;

(3) a well house is open and accessible if trespassing occurs; and

(4) a trailer used during the remedial investigation is present and accessible should trespassing occur.

A debris pile resulting from the demolition of a wastewater above ground pool (used during site remedial activities) is covered with a tarp, but is accessible. In addition, a fenced in area located near the area of the former tank farm contains barrels of contaminated material and debris. Although some of the items mentioned above would be accessible to an unauthorized individual present on-site, the likelihood is remote that such an individual will gain entry to the site. The site is fenced and, in areas, doubly fenced, and the fence is topped with barbed wire. The gates in the two access areas are well maintained, and warning signs are prominently placed. Clean Harbors, Inc. of Braintree, MA walks the perimeter of the fence twice weekly to check for evidence of fence damage or unauthorized entry.

Pathway Analyses

A. Environmental Pathways (Fate and Transport)

1. Hydrogeology of the Site and Study Area

To better understand the environmental fate and transport processes influencing the contaminants in the site and study area, a brief description of the geologic features and hydrogeologic characteristics is presented here. A more thorough presentation of the geology/hydrogeology of the site and study area is given in the various EPA Remedial Investigations [22,42,43]. The information presented here was obtained from those documents.

Overall, the surface topography at the site tends to slope eastward to the Cochato River. However, the topography varies locally. The area extending from South Street to just east of the railroad tracks has an elevation of 170 feet median sea level (MSL) in the west to 130 feet MSL in the east. The former tank farm area slopes both to the former building area and to the unnamed brook and associated wetlands west of the railroad tracks. The former building area slopes toward the clay cap area, and, until the site was regraded in 1983, toward the seasonally wet area and northern wetlands. The clay cap area slopes toward the Cochato River and toward the northern and southern wetlands. The northern and southern wetlands grade toward the Cochato River. The seasonally wet area slopes toward the South Street wellfield, and the unnamed brook toward the northern wetland and Cochato River.

The unconsolidated or overburden materials at the site and study area are characterized as glacial deposits with overlying organic deposits or fill. Generally, at the more elevated areas, e.g. the plant area, surface fill is

underlain with glacial till followed by bedrock which at the surface may be fractured into boulders and cobbles. The areas downslope (e.g., the clay cap area, the South Street wellfield, the seasonally wet area, and the portion of the site east of the Cochato River) tend to have varying thicknesses of glacial outwash between the fill and till layers. In the southern and northern wetlands and the wetlands located north of the tank farm, organic deposits are underlain with outwash followed by, in the areas of lowest bedrock elevations, ice contact deposits then till, and in the higher bedrock elevations, till. In both the southern and northern wetlands, ice deposits are present in the sections closest to the facility/cap area.

The on-site bedrock surface topography is irregular. The bedrock surface tends to slope from west of the plant area eastward to the clay cap area. A bedrock depression or bowl exists beneath the cap and the wetlands located just east and south of the cap. Two bedrock troughs radiate from the depression, one to the northwest and a lesser one to the northeast. The northwest trough lies parallel to the Cochato River. Going north from the southern to northern wetlands and along the Cochato River, the bedrock surface rises. A buried bedrock hill is located beneath the pasture south of the site and east of the South Street wells. East of the Cochato River, the bedrock surface inclines eastward.

The bedrock itself is characterized as Salem Gabbro-Diorite with intrusions of Dedham Granodiorite. The extent of weathering and fracturing of the bedrock varies from place to place, and can be extensive in areas. Contact points between the gabbro-diorite and granodiorite are highly fractured. In general, the non-weathered (competent) bedrock surface is more variable in topography than is the weathered bedrock/till layer. For instance, the depression described above may be filled with as much as 60 feet of weathered bedrock and till.

Most water at the site and surrounding areas ultimately discharges to the Cochato River. Surface drainage follows the slope of the land as described above, that is, to the wetlands and unnamed brook, and then into the Cochato River. Forty-four per cent of the contaminated soils on-site are in areas considered wetland. The unnamed brook passes through a culvert beneath South Street, through the wetlands north of the former tank farm, beneath the railroad tracks via a culvert, into the northern wetlands and finally empties into the Cochato River just north of the clay cap area. Prior to the northern wetlands, the unnamed brook is a losing stream (discharges its water into the ground water aquifer).

The ground water in the overburden aquifer in the area flows from west to east discharging into the Cochato River (see figure A-4). A local ground water divide appears to be present on-site just east of South Street. A component of the overburden ground water flows from the site, beneath the Cochato River, to just east of the river. Here, the water contacts the ground water flowing westward from the Cochato Industrial Park to the Cochato River. The site ground water is thought to travel here because of the more gentle ground water gradient east of the Cochato River (bedrock slope is shallower), and the silt lining the Cochato River may be too dense to allow total discharge. The ground water flow direction does not appear to have much of a northerly component (the direction of surface water flow in the Cochato River), and this is probably due to the very gentle gradient in this area, and the existence of a local northerly trending bedrock incline beneath the Cochato River. The natural ground water flow at the site has been altered by man historically via pumping of the South Street Wells, and at present via installation of the clay and synthetic caps and operation of a ground water recirculation system. Details are given in the following section on "Contaminant Fate and Transport" as needed.

Near the site, the Cochato River is a shallow, slow-moving stream located at an elevation of 119 feet MSL. Sediments in the river consist of an upper layer of organic deposits and an underlying layer of silt and sand. The depth of the organic rich layer varies from place to place, and is dependent upon the presence of overhanging trees and brush, and on areas favoring sediment deposition (i.e., where stream flow is slow, that is, the inside curves of the river and in ponds/lakes). Sixty-six per cent of the contaminated soils on-site lie within the Cochato River's 100-year floodplain elevation of 126.9 feet MSL (see figure A-5), and this includes the clay cap.

The Cochato River originates 2,600 feet south of the site. At least two tributaries empty into the Cochato River upstream of the site. The unnamed brook converges with the river within the site boundaries. The river flows north from Holbrook, along the Randolph/Holbrook border, and into Braintree. The watershed for the Cochato River lies within these three towns and encompasses 12.5 square miles (see figure A-6).

About 2,800 feet downstream of the site, the Cochato River passes Sylvan Lake. Normally, the Cochato River does not flow into the lake because of an elevated inlet; however, at times of flooding, waters from the Cochato River will flow into Sylvan Lake. Further downstream (about one mile from Lake Holbrook), the Cochato River passes through the Ice

Pond. From the site to the ice pond, the river channel is well developed with defined banks. North of the ice pond the channel becomes less well-defined, with the channel split by bars in areas and, elsewhere, the banks have a more gradual slope and an extensive wetland area. A number of tributaries converge with the river downstream of the site. The major ones are: Mary Lee Brook, Glovers Brook (1.8 miles from Lake Holbrook), Tumbling Brook, Cranberry Brook (3.3 miles from Lake Holbrook), and Martin Brook (3.4 miles from Lake Holbrook). A number of wetlands are located along the Cochato River.

Three miles from the site, the Cochato River passes the Richardi Reservoir. In the past until 1983, a sluice gate was used to divert Cochato River water to the reservoir as needed. The water is pumped from the Richardi Reservoir to the Upper Reservoir usually during dry spells. From the Upper Reservoir, the water drains to the Great Pond by gravity. The Great Pond is a source of drinking water for the towns of Braintree, Holbrook, and Randolph. Once past the Richardi Reservoir, the Cochato River merges with the Monatiquot River in Braintree which ultimately converges with the Fore River in Weymouth. The Fore River discharges into the Massachusetts Bay.

2. Contaminant Fate and Transport

Since 1984, monitoring for environmental contaminants has been extensive for both the Baird and McGuire site and the affected areas. A total of 102 chemicals have been detected in the various on-site media. Generally, with the few exceptions given throughout this section, the monitoring data are sufficient for the purpose of the Public Health Assessment. Prior to 1984, much less monitoring data are available. Because interim remediation activities and changes in natural resource use have altered the extent of environmental contamination and the direction of environmental pathways, the changes in contamination and pathways will be considered from a historical perspective.

To further understand the potential future environmental pathways, a brief description of the planned remediation is necessary. At this time, permanent remediation is in the preliminary stages, and on-site activities are just beginning. Remediation has been split into three parts [30-33]:

(1) Ground water treatment

* The overburden ground water contamination will be intercepted using a wellpoint pumping system, and the water treated for metal and organic contaminant

removal. The treated ground water will then be discharged into the ground water via recirculation basins.

* The sludge resulting from the ground water treatment train will be incinerated and disposed of as described below.

(2) Soil incineration and on-site disposal.

* Soils will be excavated from the areas of greatest contamination (i.e., the synthetic cap and clay cap areas, the unnamed brook, the wetlands between the clay cap and the Cochato River, part of the seasonally wet area, and part of the southern and northern wetlands). Excavation depths will vary, but generally will be to the water table. In areas, the water table will be lowered in order to increase the excavation depth. Excavation depths will be greater in the cap areas and shallower in the wetland areas. About 150,000 cubic yards will be excavated. Excavation will occur from the upland areas to the wetlands.

* Flood protection measures will be placed near excavation areas as needed.

* Excavated soils, dioxin-containing building debris, and sludge from the ground water treatment train will be incinerated using an on-site incinerator.

* The incineration ash will be used to backfill excavated areas on-site in compliance with Resource Conservation and Recovery Act of 1978 (RCRA) landfilling requirements. Each batch of ash will be tested for leaching potential. If the batch fails, it will be mixed with Portland Cement to stabilize it. The batch will be tested again, and, if needed, more Portland Cement will be added until stability is achieved. The ash will be backfilled into excavated areas near where it originated.

* Air monitoring for volatile organic compounds and particulates will be conducted during soil excavation and incineration.

* The wetlands will be restored.

(3) Cochato River sediment excavation, incineration, and on-site disposal.

* Sediments from the bed of the Cochato River are to be excavated to an average depth of 6 inches for a total

volume of 1,500 cubic yards. The portion of the river to be dredged will extend from near the clay cap to just north of Union Street and south of Sylvan Lake.

* Silt curtains will be placed during excavation, such that, downstream transport of resuspended sediment will be minimized.

* The excavated sediment will be trucked to the site, and incinerated using the same incinerator as above.

* The ash will be used to backfill excavated areas on-site in compliance with RCRA landfilling considerations.

* Clean fill will be added to the portion of the river bottom located near the clay cap, that is, near the ground water plume.

* Long-term sediment monitoring of the Cochato River will be conducted downstream of the excavation area.

The discussion of the environmental pathways will be presented on a media-specific basis.

a. Soils

On-site soils in the area of the clay cap and synthetic cap are highly contaminated, and the contamination (consisting of various pesticides, organic solvents, components of creosote, and arsenic) extends from beneath the cap materials to refusal and/or the bedrock surface. The highest levels of detected contamination tended to be in the surface-most composites (0-2 or 0-3 foot vertical composites). Refer to the "Environmental Contamination and Other Hazards" section for the contaminants and levels detected. The soil contamination at the site has been extensively characterized; however, most of the soil samples are vertical composites. For the purpose of the Public Health Assessment, ATSDR prefers discrete surface samples obtained within a few centimeters of the surface. Composites could grossly over- or underestimate the actual contamination present at ground surface.

The contamination originated from intentional disposal, spills, and runoff. Until remediation activities began, barrels, discolored soils, puddles, and a green substance the nearby children called "moon gob" were evident. The contaminants found in the soils and puddles, and the composition of the "moon gob" are unknown; however, it is reasonable to assume that the contaminants present then were the same as detected following the interim remediation

activities, and that, although unknown, the levels were likely to have been higher. Prior to the installation of the caps in 1983 and 1985, surface soil contaminants were transported in solution or bound to particulates from this area by storm runoff into the wetlands and, possibly, by fugitive dust generation and vapor emissions, and by company workers and children playing nearby carrying contamination home attached to their clothes and shoes. The volatile organic compounds (vinyl chloride, trichloroethylene, tetrachloroethylene, benzene, ethylbenzene, and xylenes) are particularly volatile followed by 2,4-dimethylphenol, low molecular weight PAHs (naphthalene and 2-methylnaphthalene), and some of the insecticides. Much of the clay cap area is within the Cochato River's 100-year floodplain boundary; therefore, contaminant transport could have occurred during flooding events to areas of the floodplain downstream (north) of the site. Subsurface soil contaminants, particularly the organic solvents and some of the creosote constituents, would tend to be transported with rain water percolating through the soil column to the underlying ground water. Currently these means of transport would be diminished because of the installation of the two temporary caps and the interim cleanup measures.

Soils in the wetland and seasonally wet area are contaminated to a lesser extent, and the contamination is due to intentional piping of liquid waste to these areas, surface runoff of contamination, and the discharge of contaminated ground water to these areas. The highest levels of soil contamination were detected in the surface-most composites. Refer to the "Environmental Contamination and Other Hazards" section for contaminants and levels detected. The higher levels of contaminants were detected in the northern wetland areas rather than the southern wetland areas. This difference would be expected from what is known of the transport pathways and intentional disposal activities. The contamination is widespread throughout the wetland areas; however, several observations regarding specific contaminant dispersal can be made. The contamination found in the wetlands bordering the clay cap to the southeast and south tends to consist of proportionately more of the constituents found in creosote than does areas to the north. Insecticide, 2,3,7,8-TCDD, and arsenic contamination tended to be higher in the northern wetlands. No 2,3,7,8-TCDD was detected in the southern wetlands and <1 ppb was detected in soil samples from the seasonally wet area. The tank farm wetlands to the north contained lesser amounts of the same contaminants as the northern wetlands into which it drains.

Wetland soils tend to be relatively anaerobic, reducing environments, and, under these conditions, arsenic could be

reduced and methylated by microbial organisms to volatile forms of arsenic: arsine, methylarsine, dimethylarsine, and elemental arsenic [1]. This process could also occur in other anaerobic/reducing environments, such as, sediments (from where the new arsenic species could partition to the surface water) and flooded areas. The species of arsenic present and the predominance of specific transport routes [(1) binding to soils, sediments, and particulates, thus, surface runoff, sedimentation, and atmospheric wet or dry deposition; (2) volatilization following reduction or methylation; and (3) solubilization, thus, transport with water flow] are dependent upon the physical and chemical characteristics of the soil and ground water and the presence of microflora, and the species of arsenic present would change as conditions change. Monitoring data are not available for the different species of arsenic.

The various insecticides detected (4,4'-DDT, 4,4'-DDE, 4,4'-DDD, chlordane, dieldrin, lindane, alpha-BHC, and delta-BHC) tend to bind more to organic-rich soils than to sandy soils; therefore, the insecticides are found more in the surface soils than in the subsurface soils. The herbicides, 2,4-D and 2,4,5-T, tend to accumulate less in soils than the insecticides discussed above, but do tend to bind to organic soils more than to sandy soils. In the area of the two caps where extensive contamination occurs, very high levels of insecticides are detected throughout the overburden. This occurrence may be due to the disposal of waste into pits in the lower area, but may also, in part, be due to the presence of high levels of organic solvents which may aid in the leaching of the insecticides through the soil column. No information is available to indicate whether this process could occur. However, at least for 4,4'-DDT, its metabolites, and chlordane, the levels detected in some ground water samples were approaching the water solubility limits for these compounds. Whether these samples were filtered prior to monitoring is unclear. Chlordane, DDT and its metabolites, dieldrin, and methoxychlor have been detected in the soils below the water table in the field east of the South Street wells. Their presence here is probably due to induced infiltration from the site during the pumping of the wells. See the following section on groundwater for more details.

Some of the pesticides (chlordane, 4,4'-DDT, 4,4'-DDE, lindane, alpha-BHC, some forms of 2,4-D, and delta-BHC) will volatilize from soils and surface waters. The relative rate of volatilization will depend upon each pesticide's vapor pressure, water solubility, and ability to bind to soils, as well as on the composition of the soil, ambient temperature, turbulence of the water, wind speed, etc. The rate of volatilization will be much slower than for the more

volatile organic solvents. Most of the chlorinated insecticides are relatively stable in the environment; however, degradation pathways relative to the soil do occur and contribute to the decomposition of the insecticides. Microbial degradation of 4,4'-DDT can occur, and results in the formation of 4,4'-DDD (anaerobic conditions) and 4,4'-DDE (aerobic conditions) [1]. The aerobic process is slower than the anaerobic process. Aldrin is converted to dieldrin by epoxidation in aerobic soils and in soils containing microbial flora [1]. Dieldrin has been detected in on-site media at greater levels and with higher frequency than has aldrin. Whether dieldrin was processed at the site or if the detected dieldrin is a breakdown product of aldrin is unknown. The BHC isomers can be microbially degraded or transformed by a variety of flora, and result in a variety of breakdown products depending upon the isomer and species of microorganism [1]. Generally, lindane appears to be transformed more readily under anaerobic conditions and alpha-BHC more readily under aerobic conditions. In water, lindane can be hydrolyzed under alkaline conditions.

The herbicides, 2,4-D and 2,4,5-T, are not persistent in aerobic, moist soils high in organic content, because they are readily degraded by soil microorganisms. The half-life of 2,4-D varies depending upon soil conditions, but ranges from 14 to 41 days with an average of 20 days [74]. No information was available for their persistence in anaerobic conditions. The phenoxy herbicides tend to hydrolyze in moist soils to the acid forms, and then may dissociate to a certain extent to an anionic form [74]. The highest levels of these two compounds in soil were detected near the railroad track between the storage building and laboratory/mixing buildings. In this area, about one foot of material consistent with the clay cap is located. In one of the 1-3 foot composites taken from this area, the highest soil levels of herbicides were detected at 17,000 ppb 2,4-D and 13,000 ppb 2,4,5-T. This composite represents what would have been once surface soils prior to the installation of the clay cap. Little 2,4-D or 2,4,5-T has been detected in the surface-most composites (0-1.5 foot composites) from the site, and is likely due to rapid microbial degradation. At one time, the levels of 2,4-D and 2,4,5-T were probably much higher. These herbicides have been detected in the deepest composites obtained at the facility area (20-22 foot composites). When present in surface soils, surface runoff of 2,4-D and 2,4,5-T has been shown to be an important transport mechanism; therefore, transport to the wetlands and seasonally wet area may have occurred in the past. Because of the short half-life in surface soils, this supposition is difficult to confirm. In subsurface soils below the water table, 2,4-D has been detected in the South Street wellfield (10-12 feet) and in the southern wetland

(4-6 feet and 10-12 feet) at levels ranging from 91-250 ppb. Its presence here may be due to induced infiltration during well pumping, but cannot be ascertained. The two monitoring wells closest to South Street wells #3 and #2 contain low levels of 2,4-D (0.31-0.45 ppb).

A dioxin, specifically 2,3,7,8-TCDD, has been detected in the surface soils at the site. The predominant locations where dioxins have been detected are the northern wetlands and the area of the synthetic cap. Other areas with known dioxin contamination are the clay cap area and the seasonally wet area. The surficial distribution of dioxins in soil is sporadic, and appears to be attributed to surface runoff and flooding events. Monitoring of soils from areas not directly in the path of surface water runoff from the facility area did not result in the detection of 2,3,7,8-TCDD (residential areas along South Street, the South Street wellfield, and the southern wetland). A number of herbicides were processed at the BMCCI facility. Herbicides, which have been detected in on-site media and may have been sources of the dioxin contamination, are 2,4,5-T and 2,4,5-trichlorophenoxypropionic acid (2,4,5-TP or silvex). 2,4,5-T and 2,4,5-TP are more water soluble, less persistent, and bind much less to soils than does 2,3,7,8-TCDD. Determining the areas of likely dioxin contamination cannot be predicted based on the presence of 2,4,5-T or 2,4,5-TP, because different environmental transport pathways and fate affect the two herbicides and the dioxin (e.g., 2,4,5-T and 2,4,5-TP affected more by ground water flow and degradation vs. 2,3,7,8-TCDD more apt to be transported bound to soils by storm runoff and to be bioaccumulated).

The application of DDT to wetland areas was conducted by Norfolk County for several years prior to 1973 for mosquito control [42]. The result of these applications was a background DDT/DDE/DDD contamination (maximum concentrations of 32 ppb 4,4'-DDT, 98 ppb 4,4'-DDE, and 30 ppb 4,4'-DDD) in the organic-rich surface soils of the wetland and field located upstream of the site. Chlordane and dieldrin were not detected in the surface soil composites from this area.

Refer to the upcoming section on sediments, surface water and fish for a discussion of the contaminated soil's impact on the Cochato River and its associated downstream wetlands and water bodies. Refer to the following section on ground water for specific discussions on contaminated soil's impact on ground water contamination.

Based on wipe tests and monitoring of dust and sawdust, the facility's buildings were found to contain elevated levels of chlordane, 4'4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,3,7,8-TCDD,

and lesser amounts of alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, dieldrin, endrin, heptachlor and its epoxide, endosulfan I, and endosulfan sulfate [87,88]. The buildings have been demolished, and the debris stored in the secured and alarmed storage building. Should a fire occur, these compounds could be dispersed with the smoke plume, and fallout with the soot.

During soil excavation activities, contaminants can be transported by surface runoff/flooding, fugitive dust generation, and vapor emissions. However, transportation of contaminants by surface water runoff and flooding should be reduced because of the planned use, if needed, of flood protection measures near excavation areas. Vapor emissions should be less than otherwise would be expected because excavation into the water table will not occur. The excavated soils and sediments, building debris, and water treatment train sludge will be destroyed during remediation. Remediation could result in the emission of contaminated small-sized particulates if appropriate engineering controls are not implemented. Contaminants of concern include (1) arsenic, (2) chlorinated dioxins which require optimal conditions to be destroyed and which may be created during remediation under less optimal conditions, (3) chlorinated dibenzofurans which can also be created under some conditions, and (4) any residual pesticides not destroyed during remediation. Because of the number and concentrations of contaminants found on-site, the contaminant residues remaining or newly created during remediation would be difficult to predict. Small-sized particulates can be transported a distance from the site. Engineering controls should remove much of the small particulates generated. The maximum stack emission level for arsenic was selected by EPA following consideration of Massachusetts and federal regulations and guidelines. The most conservative (lowest) value was selected as the maximum emission level. Particulates and volatile organic compounds will be monitored in the ambient air on-site and off-site during remediation.

The remediation by-products will be used to backfill the excavated areas on-site in compliance with RCRA landfilling requirements. Most of the backfill areas are located within the Cochato River's floodplain, in wetland areas, and in areas of low water table. Arsenic's chemical and physical properties (e.g., water solubility, volatility, and ability to bind to soils) are influenced by environmental conditions and the presence of microorganisms; thus, especially in wet areas, the species of arsenic present and its mobility are not expected to remain static. Landfilled remediation by-product containing residual contamination might result in the leaching of contaminants (especially arsenic) into the

ground water and transport with ground water flow, and with precipitation and/or flooding resulting in the surface runoff of particulate-bound contaminants (e.g., chlorinated dioxins, chlorinated dibenzofurans, residual pesticides, and arsenic). The contaminants would then be available for uptake by plants and animals (particularly aquatic animals), and, if present, the polychlorinated dioxins and dibenzofurans and residual pesticides could bioconcentrate and bioaccumulate. A study was conducted by Karasek et al. [67] of the leaching of organic compounds from a municipal incinerator's fly ash by water at different pH's. In this study, leaching of low levels (low ppb range or less) of PAHs, phenols, polychlorinated dibenzofurans and dioxins, and other chlorinated compounds occurred regardless of pH. No information was presented regarding pesticides or inorganic compounds. An off-site test burn of the site's soils was conducted to ensure that the organic contaminants will be destroyed and that air emissions will comply with established guidelines and regulations. A leachate test of the test-burn by-product indicated that arsenic was transformed from a relatively immobile form to a mobile, water-soluble form [110]. Screening of arsenic levels for each batch of by-product is planned to determine when stabilization is warranted [110]. If needed to reduce the leaching of arsenic, the remediation by-product will be mixed with Portland Cement to increase stability. In addition, the by-product will be backfilled into areas near the original excavation area; thus, by-product originating from the most highly arsenic contaminated area (i.e., near the caps) should not be backfilled into the wetland areas. This plan should greatly reduce the effect of moisture and microbes on arsenic mobility. An on-site trial burn is scheduled to ensure the destruction of TCL constituents as well as polychlorinated dioxins and dibenzofurans. During soil remediation, monitoring of by-product for TCL constituents and dioxins will occur whenever operational parameters change.

b. Ground Water

The overburden ground water contamination is mostly contained within the site boundaries (see figure A-7). The highest levels of contamination are detected in the area near the clay and synthetic caps, especially near the location of the former facility buildings. Throughout this area, high levels of benzene (>200 ppb), ethylbenzene (>1000 ppb), vinyl chloride (>100 ppb), total xylenes (>4000 ppb), 2,4-dimethylphenol (>1000 ppb), PAHs (6000 - 20000 ppb) comprised mostly of naphthalene and 2-methylnaphthalene, arsenic (500-3500 ppb), and various pesticides (up to 2.8 ppb 4,4'-DDE, 53 ppb 4,4'-DDD, 32 ppb chlordane, 8.7 ppb lindane, 1.6 ppb alpha-BHC, 0.18 ppb dieldrin, and 18 ppb

2,4-D, and 18 ppb 2,4,5-T) were detected. Other pesticides were detected in the ground water, and include endrin, aldrin, delta-BHC, and trace amounts of 2,4,5-TP. Free product, consisting of creosote and, probably, pesticides which are more soluble in organic solvents, has been observed floating on the water table near the clay cap. The actual composition of this free product is not available; however, a recovery well is intercepting and retrieving the free product.

From the clay/synthetic cap area, the contaminant plume travels with the natural overburden ground water flow direction, that is, downward and eastward until near the wetlands bordering the Cochato River where the ground water discharges upward into the wetland and river. Refer to the following section on sediments, surface water, and fish for discussions on contaminated ground water's impact on the Cochato River. A component of the overburden contaminant plume extends to just east of the river where it meets ground water flowing from the east. In the overburden on the eastern side of the Cochato River, the highest levels of contamination were detected directly across from the clay cap, and compounds detected include benzene, ethylbenzene, xylenes, vinyl chloride, PAHs, 2,4-dimethylphenol, 4,4'-DDE, 4,4'-DDD, chlordane, lindane, 2,3,5-T, and 2,4-D, and lesser amounts of 2,4,5-TP, arsenic, and dieldrin. Lower amounts of these same chemicals were detected to the north across the river from the unnamed brook. The plume does not follow the direction of surface water flow in the river bed due, probably, to the gentle hydraulic current in the area and to the existence of a local bedrock incline in the direction of surface water flow.

The plume extends to just north of the unnamed brook and south to the northern part of the southern wetland. The contaminants detected in the overburden monitoring wells along the unnamed brook and in the northern wetland consist mostly of insecticides (dieldrin, chlordane, 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, lindane, 2,4-D, endrin, and alpha-BHC), and arsenic (up to 980 ppb). The contaminants detected in the overburden wells of the southern wetland consisted of trace levels of contamination, mostly, volatile organic compounds, insecticides, and low molecular weight PAHs (mostly naphthalene, 2-methylnaphthalene, and acenaphthene) near the northern perimeter of the southern wetland. One well located south of the site trailer along the unpaved access road contained 254 ppb arsenic. No upgradient (west) overburden monitoring was conducted.

Most of what is known of the environmental transport of contaminants in the bedrock aquifer was obtained from the Phase I RI. The competency of the bedrock surface appears

variable throughout the site; however, the majority of the bedrock wells are located in moderately to highly fractured areas. Most of the wells are installed in shallow bedrock at depths less than 10 feet. The bedrock aquifer is hydraulically linked with the overlying overburden aquifer. Generally, the direction of shallow bedrock water flow tends to follow the slope of the bedrock surface. The direction of ground water flow in deeper bedrock fractures is unknown, but is expected to be somewhat random. Near the location of the former facility, the shallow bedrock ground water flow is downward, and the two barcad samplers installed 7.5 and 17.5 feet into the bedrock contained extensive chemical contamination (insecticides, volatile organic compounds, two ring PAHs, and methylated phenols). The shallow bedrock well located just east of the clay cap contained many of the same contaminants, but at lower levels except for pesticides which were detected at similar levels. Bedrock ground water located close to the river is expected to have an upward gradient, but no proof is available; however, the shallow bedrock ground water samples obtained near the river contained lower levels of contamination than did the upgradient samples and may be due to the discharge of bedrock ground water into the overburden aquifer. Shallow bedrock contamination was observed in the northern wetlands, near the Cochato River, in the southern wetland near the unpaved access road, near the unnamed brook, and west of the tank farm. Most of the shallow bedrock contamination consisted of low levels of insecticides, especially, dieldrin, chlordane, 4,4'-DDT, and 4,4'-DDD. The bedrock wells located west of the tank farm (908 and 920) were not installed at optimal depths to intercept ground water contamination. These wells were installed at shallow depths (28-33 and 7-13 feet below ground surface, respectively, and 5-10 and 2-8 feet below bedrock surface, respectively). The elevations of the bedrock surface at the well locations are higher than that at the facility, and the elevations of the screening zones, especially for Monitoring Well 920, correspond more to that of the overburden of the contaminated areas to the east. In addition, Monitoring Well 908 was installed in bedrock which is only slightly fractured. Despite this, Monitoring Well 908 contained low levels of PAHs (40 ppb each of naphthalene, phenanthrene, and 2-methylnaphthalene), 4,4'-DDT (0.36 ppb), 4,4'-DDD (0.16 ppb), aldrin (0.06 ppb), and 2,4,5-T (0.20 ppb). To better intercept bedrock ground water contamination migrating from the site, deeper bedrock wells would need to be installed and monitored. However, although no deep bedrock wells have been monitored, it would be difficult to predict where to install the wells, because fracture location and pathway are difficult to determine. In addition, remediation of deep bedrock ground water

contamination is difficult, if not impossible, to accomplish.

In 1984, an interim ground water recirculation system was installed as a short-term measure to contain the ground water contamination on-site, such that, lesser amounts of ground water contaminants would discharge into the Cochato River and associated wetlands [46]. Two overburden interception wells were installed immediately downgradient of the clay cap and 100 feet west of the Cochato River, and five recharge chambers were placed upgradient of the cap and downgradient of the former facility area. The lateral edges of the contained area appear to be located just north of the unnamed brook and in the northern portion of the southern wetland. The downgradient terminus of the contained area was determined to be located about 50 feet east of the interception wells. The proportion of the ground water contamination intercepted and contained by this system is not known, but GZA estimated that greater than 85% has been contained. Leakage of the system occurs north of the recharge chambers. The results of GZA's vertical flow net analysis indicated that leakage through the till and bedrock aquifers was unlikely. This analysis was simplified, and no proof was given to support this conclusion. Operation of the ground water recirculation system has resulted in the mixing of the ground water contamination, thus, a dilution of the contamination in the center of the plume and an increase in the contamination at the edges of the area influenced by the system. Flushing of the component of the plume located downgradient of the contained area is expected to occur with time; however, monitoring of water samples from piezometers and seepage meters located in the bed of the Cochato River during the Cochato River Sediment Study and the Phase II RI indicated that contaminants were still discharging to the river.

Air monitoring for contaminants at the recharge galley detected the presence of trace levels of naphthalene (0.07 ug/m^3) and 2-methylnaphthalene (0.04 ug/m^3), and indicated the volatilization of contaminants from this system. Ambient air data for the volatile organic compounds were not available. Generally, the contaminants would dissipate rapidly depending upon meteorologic conditions.

During soil excavation and ground water treatment, ground water contaminants would be exposed to the air, and could become volatilized, especially, vinyl chloride, trans-1,2-dichloroethylene, benzene, ethylbenzene, xylenes, methylated phenols, and, to a lesser extent, naphthalene and 2-methylnaphthalene. At this time, no volatile organic compound monitoring data are available for the site;

however, monitoring for less volatile compounds resulted in the detection of naphthalene and 2-methylnaphthalene near the recharge chambers. The EPA plans to have volatile organic compound and particulate monitoring during remediation, and to establish action levels for worker and public safety in case detection occurs. Sludge generated from the ground water treatment train will also be remediated, then, pending compliance with the RCRA landfilling requirements, the final by-product will be used to backfill on-site excavation areas. The by-product is expected to contain arsenic and, perhaps, remediation generated residual contaminants.

North of the wetland located near the former tank farm area, soil bore monitoring indicated the presence of site-related contaminants from the ground surface to below the water table (the water table is located at about 8 feet below surface level). The maximum concentration of contaminants detected frequently in this area are 15 ppb dieldrin, 320 ppb chlordane, 350 ppb DDT, 110 ppb DDE, 99 ppb DDD, and, less frequently, 22 ppm arsenic, 320 ppb 2-methylnaphthalene, and 320 ppb naphthalene. The more soluble volatile organic compounds were not detected in the soils of this area. No ground water monitoring information is available for this area; however, this area is probably crossgradient to the site. Immediately west of this area and across South Street is an operating industrial overburden well owned by Accurate Metal Finishing. Monitoring of this well for HSL inorganic and organic compounds during the Phase II RI indicated the presence of common industrial volatile organic contaminants (trichloroethylene, trans-1,2-dichloroethylene, and acetone). Of the detected compounds, trans-1,2-dichloroethylene was detected in on-site ground water samples at substantial levels and the other two compounds at lesser levels. No insecticides nor extractable organic compounds were detected in the industrial well water sample. Whether this well is diverting site-related ground water contaminants is uncertain, but, at this time, it appears unlikely that the site is the source of the contamination detected in the well.

The South Street municipal wellfield on the southern border of the site operated from the mid-1950's until 1982. Available information was obtained from the Phase I and II RI's and other reports, and from discussions with two hydrogeologists who worked on the site [19,87] and the current Chairman of the Holbrook-Randolph Joint Water Board [110].

Evidence indicates that these wells intercepted site-related contaminants, but all the contaminants intercepted and the

extent of interception are unknown. A limited amount of monitoring was conducted during the years of well operation, and monitoring was conducted mostly for phenols and select volatile organic compounds. As early as November, 1958, phenols were detected in well #3 located closest to the site. Phenols were again detected in well #3 during 1959 and 1960. In 1970, monitoring of wells #3 and #1 detected the presence of phenols in both wells. Monitoring for select volatile organic compounds in 1980 resulted in the detection of contaminants in all three wells, and at levels above federal standards in wells #2 and #3. Other chemicals of concern that were not monitored include pesticides, arsenic, and the components of creosote, specifically, methylated phenols and the more water-soluble low molecular weight PAHs (such as naphthalene, 2-methylnaphthalene, and acenapthene).

During the years immediately following 1959, investigations indicated that the contamination was present in soil borings obtained from the site to just south of well #3 and north of well #2, and noted the observation that yellow-green liquid had been discharged into the nearby seasonally wet area. Although the BMCCI rerouted a discharge pipe away from this area, continued contamination of this area was observed into the 1970's. This contamination was attributed to surface runoff. At times, the dirt access road would wash away during rain storms and runoff from the seasonally wet area to the southern wetlands would occur. In addition, runoff from the former disposal pit area (currently the clay cap area), discharge of contaminated ground water, and intentional disposal would also contaminate the southern wetlands.

Whether the wells diverted contaminated ground water from the facility or just the seasonally wet area and southern wetland is unknown because no aquifer test has been conducted to determine the capture zone. The pumps to the wells have been vandalized and, therefore, a model was developed by consultants (GHR Engineering Associates, Inc.) to the EPA in order to establish the likelihood that the wells could have diverted ground water from the facility area. Few details were available about the model, but it is known that the model entailed the pumping of all three wells under two different pumping rate scenarios (at capacity and at more realistic rates). From the model, it was determined that the pumping of all three wells could divert contaminated water from beneath the facility.

A major limitation to this model is that rarely were all three wells pumped. Well #3 was shut down from 1959 until 1968 then shut down again until 1978 when it was reactivated and pumped to waste in an effort to cleanse the aquifer of

contaminants. Well #2 was pumped intermittently when needed, but, when not in use, was not pumped to waste in order to minimize the drawing of contaminants further into the wellfield. Well #1 was on-line virtually continuously.

Well #3 is the well closest to the site, and had the highest potential yield (1,000 gpm) of the three wells. A pump test was conducted for this well in 1959 or 1960 by Northeast Consultants, Inc. on behalf of the Town of Holbrook. It is unknown whether wells #2 and #1 were pumping at the time of the test. Based on a resistivity survey following injection of a saline solution into the ground between the facility area and well #3, this well drew water from the seasonally wet area and from the neighboring wetland. The pumping of this well would be more apt than wells #2 or #1 to draw contaminants from the facility area into the wellfield. Whether this well supplied water to the municipal system after 1959 is uncertain. When this well was pumped to waste, it would act as a ground water barrier during the time of operation, such that, additional contaminants could not have been drawn from the facility and captured by wells #2 and #1. Once the well was shutdown, the contaminated water drawn towards well #3 could then be available for wells #1 and #2. From the available information, Well #3 was operated in 1968 and 1977-1980, and may have been pumped to waste; however, well #1 was found to be contaminated with phenols by 1970. Well #3 was operated for a short period in 1958-1959, and, perhaps, occasionally thereafter at least to obtain samples for phenol monitoring.

Wells #2 and #1 are located further from the site than well #3, and have lower potential yields (250 and 175 gpm, respectively). Whether these wells could have diverted water from beneath the facility or only from the southern wetlands and seasonally wet area and water previously drawn into the wellfield from operation of well #3 is unknown.

Because of (1) the complicated bedrock features beneath the wellfield, (2) the presence of unconsolidated deposits with differing hydraulic conductivities, (3) incomplete characterization of the overburden and bedrock geology of the wellfield area, and (4) the uncertainties regarding the pumping histories, it would be difficult to predict the shape and extent of the capture zone for the municipal wells. Bedrock features that could particularly affect the capture zone are (1) the presence of a buried bedrock hill located between the wellfield and the Cochato River, (2) the presence of a valley wall to the west of the wellfield, and (3) the presence of a bedrock depression in the area of the southern wetland and clay cap located east of the unpaved access road and facility area and north of the buried bedrock hill. The bedrock surface grades downward somewhat

gradually from the facility area along the access road to the wellfield. From the northern edge of the clay cap, the bedrock surface grades towards the bedrock depression (clay cap area and southern wetland) before inclining up the buried bedrock hill. The area encompassed by the buried bedrock hill is unknown, but the part of the hill nearest well #3 lies at an elevation of 100 feet MSL, whereas well #3 was installed to about a depth of elevation 70 feet MSL. The screen length of the well is unknown, but, based on a 1958 letter from the Randolph-Holbrook Water Departments to the MDPH, the intention was to install a 15 foot screen at a depth from surface of 61 feet. The competency of the bedrock hill is unknown; however, the portion of the bedrock hill located near well #3 is overlain with about 30 feet of sorted unconsolidated deposits. The extent of fracturing of the bedrock, the composition of the overlying deposits, the elevation of the water table at the hill, the area encompassed by the hill, and the grading of the bedrock hill would influence the extent to which the aquifer in this area contributes to the recharge of the municipal wells and the extent to which the bedrock hill acts as a ground water barrier and distorts the capture zone.

It is possible that the capture zone could be skewed in a north-south axis, such that, the facility area and clay cap area would be more apt to contribute ground water to the wellfield by induced infiltration than if the buried bedrock hill did not exist. The pumping of the wells has not resulted in any observed impact on the Cochato River and associated wetlands [111], and, if this observation is correct, it may be due in part to the presence of the bedrock hill between the wells and the river. Even if the river does not recharge the South Street wellfield during periods of pumping, the pumping of the wells would divert ground water that, under normal conditions, would eventually discharge into the river. Any future modeling for predicting the capture zone of the wells should consider the pumping history of the wells, as well as, the bedrock features and hydraulic conductivities of the unconsolidated deposits in the area, and the potential for contribution by the Cochato River and its associated wetlands.

In 1985 during the Phase II RI, subsurface soil bore monitoring in the wellfield indicated the presence of site-related contaminants below, but not above, the water table. The contaminants [up to 480 ppb 4,4'-DDT, 430 ppb 4,4'-DDE, 2200 ppb 4,4'-DDD, 1800 ppb chlordane, 2.4 ppb dieldrin, 61 ppb methoxychlor, 270 ppb dibenzofuran, 2860 ppb PAHs (mostly due to 2-methylnaphthalene), and 8 ppm arsenic] especially were detected downgradient (natural flow conditions) of the wells in the field east of the site. The evidence indicates that contamination was drawn into the

wellfield during pumping of the wells, and, now that the ground water has resumed its natural flow conditions, the contamination is traveling with the ground water and, perhaps, discharging into the wetlands of the Cochato River east of the wellfield. The contamination detected in the field is located southeast of well #3 indicating that the contamination was drawn beyond well #3.

Except for monitoring wells placed upgradient of the water supply wells during natural flow conditions and not in the path of site-contaminated ground water transported to the water supply wells during pumping, no other monitoring wells were placed in the wellfield. The two monitoring wells (one is in the seasonally wet area, and would be downgradient when the wells are pumping) closest to the municipal wells #2 and #3 contained dieldrin and/or the herbicide 2,4-D. The soil borings closest to the water supply wells were obtained upgradient. The boring location closest to municipal well #3 contained 2,4-D contamination at a depth below the water table. The contaminants intercepted by the water supply wells are unknown, and would be difficult to determine since flushing of contaminants from the wellfield is occurring.

Site-specific chemicals which have been detected in the municipal wells consist of "phenols" (specific phenols are not known), trans-1,2-dichloroethylene, benzene, trichloroethylene, and tetrachloroethylene. Although a limited amount of monitoring data are available, the change in the contaminant concentrations captured would vary with time and are impossible to determine.

Additional site-specific chemicals have been detected in soil samples from below the water table in the wellfield. These compounds include chlordane, 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, dieldrin, 2,4-D, dibenzofuran, PAHs (especially naphthalene and 2-methylnaphthalene), and arsenic. Although these chemicals were probably drawn into the wellfield beyond well #3 by the pumping of the municipal wells, it is unknown if these chemicals were ever captured by the wells. These chemicals were not monitored for in the municipal well water, and tend to be less water soluble and to bind to soil more than the chemicals detected in the municipal water supply. Naphthalene, 2-methylnaphthalene, and some forms of arsenic tend to be more water soluble than the pesticides. The relative rate of transport to the wellfield and subsequent flushing from the wellfield for each chemical is a function, in part, of its water solubility and its inability to bind to organic or inorganic particulates. In other words, the volatile organic compounds would tend to be transported into the wellfield fastest, then the phenols, low molecular weight PAHs, and, finally, the pesticides.

Evidence of the presence of the more soluble compounds would be eliminated first (if half-life considerations are ignored) due to the flushing of the wellfield when natural flow conditions were resumed.

Other site-specific chemicals were not detected in the wellfield or were not designated as "chemicals of concern" for this Public Health Assessment. These chemicals, which may have been captured by the municipal wells, include the specific phenols (2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, etc.), vinyl chloride, xylenes, ethylbenzene, lindane, alpha-BHC, endosulfan, endrin, methoxychlor, silvex, 2,4,5-T, aldrin, etc. A total of 102 chemicals were detected on-site, and a number of them may have been diverted and captured by the pumping of the municipal wells.

The exact area receiving South Street well water as a municipal supply is not known due to a lack of information on (1) the municipal distribution system, (2) the relative contribution of each of the water supply sources at any given time, and (3) the effect of demand at any given time. Three observations were used to identify the consumers likely to have received South Street well water and were given, in part, by the Chairman of the Joint Randolph-Holbrook Water Board [111]:

(1) The water flow within the pipes would tend to follow the path of least resistance, i.e., because water enters Holbrook from Randolph at the Union Street interconnection from where it is delivered to a booster station, the water from the South Street wellfield could not flow along the South Street pipeline to the north because of the higher head pressure in that direction, but rather would have to flow south towards the Grove neighborhood and Brookville area of town. Records were obtained by E.C. Jordan regarding the direction of flow at the booster station for the years 1977-1980 [21]. Records for the years prior to 1977 were not available. During 1977-1980, some water flowed from Holbrook to Randolph. The total yearly volume for this period ranged from 33,000-741,000 gallons and averaged 501,000 gallons. What proportion of this water originated from the South Street wellfield, the Donna Road wellfield, or was previously delivered to Holbrook from Randolph is unknown.

(2) Although located immediately southeast of the Grove neighborhood, the Donna Road wellfield does not appear to have supplied water to the Grove neighborhood. This wellfield contains high levels of iron and manganese, and elicited complaints about the poor aesthetic

quality of the water from consumers in the southern area of town (South Franklin Street and the Revere section) but not in the Grove neighborhood.

(3) The Holbrook municipal water supply system is interconnected with Randolph's water supply system at Union Street and at South Street. According to the DEQE Water Supply Statistics for 1987 for the Town of Holbrook, the Union Street interconnection was open for daily use and the South Street interconnection was last used in 1980 [59]. From a conversation with the current Chairman of the Joint Randolph-Holbrook Water Board, the South Street gate valve is usually closed in order to keep the water from backfeeding into Randolph. Whether this interconnection was usually closed when the South Street wells and Donna Road wellfield were in operation is unknown.

Site remediation addresses source clean-up, but does not completely address the wetlands contamination nor the contamination east of the wells. The contamination in these areas and any residual contamination not fully contained in the source area may compromise the quality of water captured if the wellfield is used as a water supply source in the future. Site remediation entails the backfilling of remediation by-product into the excavated areas; however, remediation plans entail the solidification of the by-product, which would reduce the mobility of any residual contamination. This by-product is expected to contain arsenic and, perhaps, other residues. The relative extent of impact should be lower than in the past, and continued flushing of the wellfield could result in the eventual discharge of contaminants into the Cochato River. However, uncertainty remains as to the potential impact on the wellfield should the wells be reactivated in the future.

c. Sediments, Surface Water, and Fish

The contamination of the Cochato River sediments occurs by two pathways, and is described in detail in the Phase II RI [42] and in the Cochato River Sediment Study [22]. Surface runoff of particulate-bound contamination occurs. In particular, wastewater discharge and surface runoff to the unnamed brook entered the Cochato River just north of the clay cap. In this area, the highest levels of arsenic and insecticide (4,4'-DDT, 4,4'-DDE, 4,4'-DDD, dieldrin, chlordane, and gamma-BHC) sediment contamination were detected. The contamination was detected in all depth intervals monitored including the deepest interval of 18-36 inches.

The second pathway is ground water discharge of contaminants from beneath the bed of the Cochato River. This discharge occurs in the area of the Cochato River near the clay cap. The organic contaminants and arsenic are trapped mostly by the organic rich sediments. In this area, most of the contaminants are organic solvents/creosote constituents (ethylbenzene, benzene, xylenes, 2,4-dimethylphenol, benzo(a)pyrene, fluoranthene, other PAHs especially naphthalene and 2-methylnaphthalene, and dibenzofuran), and lesser amounts of insecticides and arsenic. Contamination is detected in all the depth intervals monitored including the deepest interval monitored (18-36 inches). Based on the difference between contamination detected in the ground water at a depth of five feet and that detected in the seepage meter, GHR has estimated that 90-100% of the organic contamination and 85% of the arsenic discharging to the Cochato River are trapped in the sediments [22]. Loading of the organic contamination and arsenic to the Cochato River has been estimated to be 4.5 and 26.7 kilograms per year, respectively, based on maximum discharge and contaminant level assumptions [22].

The contaminant plume has been estimated to discharge to the Cochato River at a maximum rate of 0.03 cubic feet per second and to represent less than 1% of the river's discharge upstream or downstream of the site [22]. Therefore, any contamination not trapped by the sediments would rapidly dissipate into the larger volume of surface water. Many of the compounds not trapped by the sediments are volatile, and could partition into the air. In the sediments, arsenic can be reduced and methylated by microorganisms under reducing conditions, and become more water soluble and volatile.

Monitoring has resulted in the sporadic, low level detection of Cochato River surface water contamination indicating that this environmental pathway is not significant at this time. In the past, episodes of creosote spillage into the Cochato River are known to have occurred, and surface water contamination may have been greater and more prevalent during that period. The most prevalent surface water contaminant detected both on-site and downstream from the site is arsenic; however, it is unknown whether the detected arsenic was particulate-bound or in solution. Lesser relative amounts and frequency of volatile organic compounds (ethylbenzene, xylenes, trichloroethylene), 2,4-dimethylphenol, naphthalene, 2-methylnaphthalene, lindane and 4,4'-DDD were detected.

Site-related contaminated sediment extends from the site downstream to the portion of the Cochato River near the Richardi Reservoir. However, much of the sediment

insecticide data for the Cochato River Sediment Study were invalidated, or were determined to be not detected because the levels detected were below the actual detection limits, which were many times higher than the contract required detection limits. The combined levels of total insecticides present at each monitoring station would represent an underestimation of the actual insecticide levels present. The available insecticide monitoring data are insufficient for the purpose of the Public Health Assessment. Downstream monitoring of the Cochato River sediment will occur during and following remediation, and should satisfy this additional data need. Monitoring of Richardi Reservoir sediments during the Phase II RI indicated that site-related sediment contamination had not yet entered the reservoir when the sluice gate was closed. Monitoring of sediments from the site to just north of Union Street and south of the Sylvan Lake is sufficient for the purpose of the Public Health Assessment.

Sediments tend to settle where the surface water flow rate is slow, that is, in the inside of river bends, in lakes and ponds, and in wetland areas during flooding events. Monitoring of the floodplains/banks of the Cochato River, the inside corners of bends in the Cochato River, and the Ice Pond indicate that the deposition of contaminated sediments has occurred in these areas. In particular, the Ice Pond contains elevated levels of sediment contamination. The predominant site-related contaminants detected are chlordane, 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, arsenic, and PAHs. PAHs are ubiquitous in the environment, and have also been detected upstream of the site and in tributaries of the Cochato River. Floodplain/bank monitoring for sediment contamination indicates the presence of site-related contaminants (insecticides and arsenic) in most of the samples. Very little floodplain/bank monitoring occurred from prior to the Glovers Brook confluence and downstream where a major wetland area is located.
The Cochato River flows into the Sylvan Lake only during flooding events. Sylvan Lake was monitored for sediment contamination at the inlet, in the center of the lake, and on the opposite shore of the lake. The highest contaminant levels were detected near the inlet followed by the shore. No sediment monitoring occurred along the portion of the shore of Sylvan Lake which lies adjacent to the Cochato River. The sediment contamination of this area should be higher than that of the opposite shore. No sediment monitoring occurred for the stretch of the Cochato River that extends from the Sylvan Lake to the Ice Pond.

The portion of the Cochato River to be remediated extends from the clay cap area on-site to just north of Union Street. Remediation entails dredging/excavation of the

sediments, transport to the site, and destruction of the organic contaminants. During remediation, sediment resuspension and transport downstream will be minimized by the placement of silt curtains just downstream of the excavation area. Ambient air monitoring for contaminants will occur during excavation. Clean organic-rich fill will be placed in the excavation area near the clay cap in order to trap any new contaminants discharging in the Cochato River. Whether this fill will be monitored periodically following remediation is unknown. Future dredging of the Cochato River for such purposes as flood control could result in transport by man of contaminated sediment to a disposal area, and the resuspension and transport downstream of contaminated sediments.

A limited amount of fish monitoring has occurred. Various species have been collected, and some of the samples represent composites of fish of a given species. Edible fillets were monitored for 2,3,7,8-TCDD. One composite was monitored for each of the following areas: (1) Lake Holbrook, (2) Sylvan Lake, and (3) the Cochato River near the Ice Pond.

No data for on-site 2,3,7,8-TCDD monitoring of fish are available. Low levels of 2,3,7,8-TCDD were detected in all three samples. The Lake Holbrook sample was obtained upstream of the site, and was expected to represent background levels of 2,3,7,8-TCDD contamination. From a conversation with a member of the Holbrook Conservation Commission and the Holbrook Health Agent, silvex was applied to Lake Holbrook one time during the 1970's to control for weed growth. Silvex is known to contain 2,3,7,8-TCDD contamination and could be the source of the dioxin contamination (1 ppt) found in the Lake Holbrook fish composite. A sample obtained from a location 6,300 feet downstream of the site contained no detectable 2,3,7,8-TCDD (detection limit of 0.5 ppt). The two downstream composites contained higher levels of 2,3,7,8-TCDD (3 ppt in Sylvan Lake sample and 4.5 ppt in sample from near Ice Pond); however, the numbers of samples monitored are too few to determine if these numbers are representative of the actual levels of 2,3,7,8-TCDD contamination present in fish in this area.

Organic contaminant monitoring occurred for six on-site (four individual fish samples and two composites) and two individual fish samples from the Ice Pond. Whether these samples are whole fish or edible fillet are unknown. The maximum levels of contamination detected in these samples are 7.1 ppm PAHs (mostly naphthalene and 2-methylnaphthalene), 0.42 ppm dibenzofuran, 0.37 ppm 4,4'-DDT, 1.0 ppm 4,4'-DDE, 4.7 ppm 4,4'-DDD, and 2.0 ppm

chlordane. The two Ice Pond samples contained as maximum levels detected 1.76 ppm PAHs (mostly not naphthalene and 2-methylnaphthalene), 0.19 ppm 4,4'-DDT, 1.2 ppm 4,4'-DDE, and 2.7 ppm 4,4'-DDD. No fish monitoring for these contaminants was conducted in Sylvan Lake where fishing is known to occur. The compounds detected in the fish samples reflected the contaminants present in the sediments of the locations monitored and the compounds known to bioaccumulate or bioconcentrate. No arsenic monitoring of fish was conducted. The principal form of arsenic in fish is arsenobetaine, although monomethylarsine and arsenite may also be present. Arsenic does not appear to biomagnify through the food chain.

d. Ambient Air

Little monitoring data are available for this environmental medium. What is known, the limitations of the data base, and the additional monitoring planned have been discussed in the previous sections.

B. Human Exposure Pathways

Because of interim remedial measures, other precautionary actions, and the closing of the facility, past human exposures were more significant than that occurring now, and, perhaps, than that likely to occur in the future. Table III presents the exposure pathways for populations most likely to be or have been exposed to contaminated media. The discussion of the human exposure pathways is divided into three main sections: (1) the facility/site and the surrounding areas; (2) the Cochato River; and (3) water supplies.

1. Facility/Site and Surrounding Areas

Human exposures to contaminated media at the facility/site area occurred in the past (before 1983). Waste disposal methods resulted in the uncontained contamination of media in areas where human contact was likely. Facility workers were most likely to have been exposed to contaminated media. The routes of exposure for waste products and each contaminated media are described below.

Wastewater was discharged to various areas of the site. Dermal contact is the most likely route of direct exposure. Some of the discharge contained volatile solvents, and, therefore, inhalation of vapors originating from the wastewater was likely to have occurred.

Solid waste was disposed on-site. Some of the waste, found in discarded barrels, was characterized by the

neighborhood children as green moon gob. Dermal contact with this waste occurred. Ingestion of the solid waste is less likely, but may have occurred. Because the composition of this waste is unknown, whether or not inhalation of contaminants originating from this waste occurred is unknown.

Many of the pesticides handled at the facility were received as a powder, and likely were dispersed in the indoor and ambient air as dusts. Residues of these dusts were found inside the facility buildings. Dermal contact, ingestion, and inhalation of these compounds probably occurred.

Surface soils throughout the facility area and neighboring wetlands were highly contaminated. Human exposure to soil contaminants could have occurred by dermal contact and ingestion. Vapors and dusts emanating from the soil could have been inhaled.

Surface waters present near the site consisted of discolored puddles and standing water in the wet areas, especially the seasonally wet area, and running water such as the unnamed brook. Dermal contact is the most likely route of direct exposure to this source of contaminants. Intentional ingestion of surface waters is unlikely due to aesthetic considerations. The waters were often discolored and odorous. Inhalation of vapors originating from the surface waters may have also occurred.

Exposure to ground water contaminants by facility workers is unlikely to have occurred, because the aquifer was not used as an industrial water supply source by BMCCI. Ground water discharges to the surface via seeps in the nearby wetlands. Dermal contact with water in the vicinity of the seeps and inhalation of volatilized compounds would be the only route of exposure to ground water contaminants.

Table III
Actual and Most Probable Human Exposure Pathways[c]

Exposed Population	Environmental Pathway	Exposure Pathway[a]	Time[b]
Facility Workers and Trespassers (including children)	1. wastewater	3	A
	2. soils	3, 2	A, B
	3. sludge (gob) solid wastes	3, 2	A
	4. dust	1, 2, 3	A, B
	5. vapors	1	A, B
	6. ground water	-------	
	7. surface water	3	A, B
Families of Workers and Trespassers	1. soils/dusts	3, 2	A
	2. gob	3, 2	A
Nearby Residents and Industrial Park Workers	1. dusts	1, 3, 2	A, C
	2. remed. particles	1, 3, 2	C
Remediation Workers	1. soils	3, 2	A, C
	2. dusts	3, 1, 2	A, C
	3. remed. particles	3, 1, 2	C
	4. ground water	3	C
	5. vapor	1	A, C
	6. sediments	3, 2	C
	7. surface water	3	C
Fishermen and Children	1. fish	2	A, B,C
	2. sediments	3, 2	A, B,C
	3. surface water	3, 2	A
Residents: especially Grove and Revere areas of Holbrook, and part of Randolph	1. South Street wellwater	2, 1, 3	A

Footnotes:
a. 1 - inhalation
2 - ingestion
3 - dermal contact

b. A - past exposure
B - present exposure
C - future exposure

c. See the text for details and qualifiers regarding actual and potential human exposures.

People trespassing the facility area and neighboring wetlands would be exposed to the same contaminated media by the same exposure pathways as the facility workers. Because non-workers occasionally accessing the area were not directly using the chemicals and were not present for similar periods of time (e.g., 40 hours per week), the facility workers were exposed to a greater extent than non-workers. Children were reported to use the facility as a shortcut from the Grove area to the nearby bowling alley. In addition, the children also played in the nearby area and were known to have throwing fights with the "moon gob." They also used to play inside discarded barrels that contained residual waste. As a result, dermal contact with soils, solid waste, and surface water occurred. Incidental ingestion of some of these same contaminated media probably also occurred. Inhalation of fugitive dusts and vapors likely occurred.

Both facility workers and children playing in the area could have transported contaminated soils, dusts, and solid wastes attached to their shoes and clothing to the floors of their homes. Their families could then have been exposed to these contaminants by dermal contact. Toddlers and infants are particularly likely to have been exposed, because they spend more time on the floor and have behavioral patterns likely to increase exposure (i.e., hand to mouth activities, thus ingestion of contaminants). Caretakers in the home were likely exposed, mostly by dermal contact, during laundering of the soiled clothing.

Workers in the adjacent industrial facilities and nearby residents may have been exposed to fugitive dusts and vapors by inhalation, and to fugitive dusts by dermal contact and ingestion. The potential for this exposure is unknown due to a lack of information; however, the likelihood would have increased during soil movement activities (e.g., the installation of the clay cap).

Early cleanup activities occurred during the early to mid 1980's. The workers may have been exposed to contaminated media, especially during the earlier activities. Following the closure of the facility, the remedial workers were more apt to have used the appropriate personnel protection and safety measures. In particular, exposure to contaminated soils by dermal contact and ingestion, to fugitive dusts by dermal contact, inhalation, and ingestion, and to vapors by inhalation may have occurred.

Current exposures to site area contaminants are greatly reduced due to the closing of the BMCCI facility, the interim cleanup activities, and the fencing of the site. Occasional exposures would result when accessing the site from soils (dermal contact, ingestion), surface water (dermal contact), dusts (inhalation, dermal contact, ingestion), and vapors (inhalation). The current site status would reduce exposures because the most contaminated

surface soils are covered with caps and the clay cap and surrounding areas are seeded with grass to reduce soil mobility (e.g., fugitive dust generation). In addition, the ground water recirculation system has decreased the amount of contaminants discharging to surface waters; therefore, exposure to this media should be reduced compared to the past. Because the site is surrounded with a barbed wire topped cyclone fence with adequate warning signs and the integrity of the fence is checked weekly, unauthorized access by adults or juveniles is unlikely. The secured storage building and its contents (dioxin and insecticide containing demolition debris) are scheduled for destruction during remediation. Should the building catch fire, the firemen, nearby industrial workers and residents could be exposed to smoke/ash by inhalation, dermal contact and ingestion. The building has been alarmed for smoke, heat and intrusion to minimize exposures.

Exposures to contaminated media could occur to workers during remediation, if proper personal safeguards and engineering controls are not used. During excavation activities, the contaminated media and the pathways of concern are soils (dermal contact, ingestion), dusts (dermal contact, inhalation, ingestion), vapor (inhalation), sediments (dermal contact), and surface water (dermal contact). During ground water treatment, exposures to ground water (dermal contact), vapors (inhalation), and treatment train sludge (dermal contact, ingestion) could occur. Industrial workers and nearby residents could be exposed to fugitive dusts (inhalation, dermal contact, ingestion) and vapors (inhalation) during remediation. During destruction of soil contaminants, exposure to small-sized particulates could occur to remediation workers and nearby residents and industrial workers by inhalation, dermal contact, and ingestion; however, this exposure should be reduced with proper engineering controls.

Future exposures to wetland sediments and backfilled remediation by-product could occur by dermal contact or ingestion, and would depend on future land use. As the result of the probable future transport of contamination from the wetland areas, the most likely route of exposure would be from the Cochato River media (e.g., ingestion of fish and dermal contact and ingestion of sediments), or consumption of contaminated-terrestrial foodstuffs if there is a land use change.

2. The Cochato River

The Cochato River and its floodplains are contaminated with site-related contaminants. Past and present exposures to contaminated sediments (dermal contact and incidental ingestion) and fish (ingestion) have occurred. Currently, the surface waters are slightly contaminated in the immediate vicinity of the site, and the routes of exposure would be dermal contact, ingestion, and inhalation of volatilized contaminants. Exposures

to Cochato River contaminants near the site are unlikely because, at this location, the river is too shallow, unattractive, and not easily accessible to support much recreational activity. Past exposures to Cochato River surface water contaminants is more likely to have occurred when creosote spills would result in the transport of creosote downstream to stretches of the Cochato River located in residential areas (especially near the Ice Pond and Sylvan Lake).

Recreational fishing is known to occur in the Sylvan Lake and, perhaps, the Ice Pond. The extent of the fishery is probably small because the size of these water bodies is small; however, it is unknown to what extent the fish from these sources contributes to the diet of each of the fishermen and their families. Children are most likely to wade and swim downstream of the site in Sylvan Lake and the Ice Pond. The extent of such activities is unknown, but would result in exposure to sediments by dermal contact and incidental ingestion.

Remediation of the Cochato River sediments will occur downstream of the site to near Union Street. Sediments downstream of this area will not be excavated, because the contaminant levels are lower beyond Union Street. Future exposure to contaminated sediments (dermal contact and ingestion) and fish (ingestion) may occur, but should be reduced. Future dredging of these downstream areas (e.g., for flood control), could result in workers being exposed to contaminated sediment by dermal contact and incidental ingestion. The people living, working or playing near the disposal area for the dredged material could be exposed to contaminants. Land use changes along the floodplain of the Cochato River, especially for residences or play areas, could result in exposure to contaminated soils and sediments by dermal contact and ingestion.

3. Water Supplies

Past exposure to contaminated South Street well water occurred. The wellfield was utilized from the mid-1950's until 1982 as a municipal water source. The actual period of time the well water was contaminated is unknown, but contaminants were known to be in the wellfield by 1958. The actual population served by this water source is not known with certainty, but is most likely the Grove area of Holbrook, the Revere section of Holbrook, and, perhaps, the part of Randolph closest to the Union Street and South Street interconnections. The neighborhood children who played near the site most likely also received South Street well water. Exposure to the well water contaminants would occur by ingestion, dermal contact during bathing or dishwashing, and inhalation of volatilized and aerosolized contaminants during showering, use of a dishwasher, hot water to launder clothes, and heating water during cooking.

Because the wellfield has been closed since 1982, this source of exposure is no longer occurring. Future use of the wellfield following remediation could result in exposure, because (1) remediation does not address all the wetland and soil contamination, (2) the ground water contamination may not be fully contained or removed, and (3) the backfilling into wetland areas of remediation by-products containing residual contamination.

The Richardi Reservoir received Cochato River water until the early 1980's, but does not appear to have received site-related contaminated sediments. As indicated in the "Environmental Pathways" section, surface water contamination was probably not significant. The Richardi Reservoir supplements the Great Pond reservoir; therefore, the chance of exposure would be further diminished by dilution. It appears extremely unlikely that the populations of Randolph, Holbrook, and Braintree would have been exposed to site-related contaminants from this source.

An industrial well is located across South Street at the Accurate Metal Finishing, Inc. facility, although it is unknown if the contamination detected in the well water originates from the Baird and McGuire site. Exposure to the contaminants in this water could occur by dermal contact and inhalation of the volatile constituents. No private residential water supply well is known to be impacted by the site, including the well located about 1/4-mile from the site. Because the direction of bedrock ground water transport and the extent of bedrock ground water contamination are unknown, it is uncertain if any private bedrock well is likely to be impacted by the site. The locations of residential bedrock wells are unknown. If the well draws contaminated water, exposure could occur by ingestion, dermal contact, and inhalation for a domestic water supply well and by dermal contact and inhalation for an industrial water supply well. Because the contaminated overburden ground water is discharging into the Cochato River and associated wetlands, exposure to site-related contaminants from overburden private water supply wells is unlikely.

Public Health Implications

The Public Health Implications section of this Public Health Assessment is divided into three subsections. The first subsection is "Toxicological Implications," which reviews the possible toxicological outcomes following exposure to Baird and McGuire site contaminants. The health outcomes mentioned have not necessarily occurred, but indicate what outcomes might have occurred and assist in identifying the outcomes to look for in the second subsection. The second subsection is "Health Outcome Data Evaluation." This subsection summarizes the results of the two existing MDPH descriptive health studies and a cancer case

study of a neighborhood in Randolph by academic investigators, and presents the findings of the new descriptive health study that was conducted for this Public Health Assessment. The current health study utilizes available cancer incidence statistics, and focuses specifically on residents of the two census tracts most likely to be affected by Baird and McGuire site contamination. The third subsection entitled "Interpretation of Toxicological and Health Outcome Information" interprets the findings of the previous two subsections in relation to each other, and assesses whether the community's public health concerns have been addressed by the Public Health Assessment.

A. Toxicological Implications

A total of 102 chemicals have been detected at the Baird and McGuire site. The chemicals determined to be compounds of concern were selected based on consideration of prevalence in environmental media, likelihood of human exposure, and toxicity. The compounds of concern are benzene, tetrachloroethylene, trichloroethylene, vinyl chloride, ethylbenzene, xylenes, 2,4-dimethylphenol, PAHs including naphthalene and 2-methylnaphthalene, 4,4'-DDT and its metabolites, dieldrin, chlordane, alpha-BHC, gamma-BHC, 2,4-D, 2,4,5-T, 2,3,7,8-TCDD, and arsenic.

The large number and concentrations of compounds present at the site make the determination of potential health outcomes difficult, because there is a limited amount of scientific knowledge about chemical interactions as they relate to human health effects (i.e., synergistic and antagonistic relationships). Exposure to a mixture of compounds may be more or less toxic than exposure to any one compound alone. A health effect resulting from exposure to a mixture may be different than the health effect expected from any one compound. The potential health impacts following exposures are described on a health outcome basis to specific potentially exposed populations, and are based on available human information (mostly occupational studies and acute poisoning cases) and, at times, experimental animal studies. If known, actual or potential chemical interactions are presented.

Mention of specific human health effects does not mean that these outcomes have occurred. Toxic effects having a threshold associated with the contaminants could happen only when exposure occurs to an extent high enough to exceed that threshold. Similarly, the risk of non-threshold effects occurring depends on exposure occurring and the intensity of that exposure. In addition, the possibility of a health effect is dependent on an individual's susceptibility to its occurrence or sensitivity to an exposure. Except for where specifically indicated otherwise,

the toxicological information were obtained from summary documents, specifically, the ATSDR Toxicological Profiles [1].

The discussion will be divided into three parts based on the predominant means/media of exposure: (1) the facility/site and surrounding areas; (2) the Cochato River; and (3) the water supplies. Each part will be subdivided into three sub-parts in order to discuss possible adverse outcomes based on past, present, and future exposures. The following discussion will emphasize outcomes that may be diagnosed rather than on vague, subjective symptoms, and will mention, if information permits, where additive or other synergistic interactions by various contaminants might occur. For many chemicals information pertaining to a specific human adverse outcome or group of outcomes is unknown. Suggestions here are based on known toxicity by a single contaminant to a target organ or system.

1. Facility/Site and Surrounding Areas

Past - Past exposure to contaminants at the facility and surrounding area occurred during the period of facility operation. The receptors most likely to have been affected are the BMCCI workers and the children who played at or near the facility. Because of the scarcity of monitoring data for the period prior to facility closing, an educated assumption is made that the contaminants present were the same as the compounds detected during the remedial investigations, but were likely at higher concentrations because of (1) the uncontrolled hazardous waste situation at the time, (2) the recent interim remedial activities, and (3) continued environmental degradation and transport processes.

Many of the potential health effects to which the workers and children may be or have been at risk of developing have shorter latency periods than does cancer, and would be expected to be manifested sooner than cancer. Some of these effects probably are reversible, although complete information is not available. The health effects to which these two subpopulations may be at risk are given below.

* Chloracne and other skin disorders - Exposure to 2,3,7,8-TCDD by dermal contact, ingestion, and occupational exposure can result in chloracne in humans [1]. The minimum dose necessary to cause this effect is unknown; however, single or multiple doses and very low doses are known to result in chloracne. Chloracne is a severe, deformative skin lesion that can take years to clear. Workers were particularly at risk for this effect, because they handled the dioxin-containing 2,4,5-T and because surface soils and the buildings at the facility were contaminated with 2,3,7,8-TCDD. The

children are less likely to have developed chloracne (unless they handled 2,3,7,8-TCDD contaminated waste product, such as sludge or waste water), because the southern wetland's surface soils appear not to be contaminated with 2,3,7,8-TCDD. Exposure to fugitive dusts bearing 2,3,7,8-TCDD could occur to both the workers and children. An individual with chloracne or other skin disorder would be particularly susceptible to contaminant exposure by the dermal route. Additional chemicals that might result in other skin disorders following dermal contact are creosote, which can result in irritated skin, lesions and ulcers [65], and arsenic dusts, which can result in local inflammation and vesiculization [1]. Occupational exposure to arsenic has also been shown to cause hyperkeratosis and hyperpigmentation.

* Cataracts - Inhalation and dermal exposure to naphthalene can result in the development of cataracts based on occupational studies [35]. The development of cataracts in humans following ingestion is uncertain, but is indicated by the results of oral studies with rabbits [35]. Creosote and/or naphthalene have been detected at very high levels throughout the site; therefore, both the workers and the children would be at increased risk of developing cataracts following naphthalene exposure. Whether or not 2-methylnaphthalene, which is present concurrent with naphthalene, also causes cataracts is unknown.

* Convulsions and other neurotoxic effects - Many of the insecticides found on-site affect the various neurotransmitter pathways. Site-related insecticides that are known to be neurotoxic include DDT and its metabolites, chlordane, dieldrin, and alpha- and gamma-BHC [1]. Whether exposure to the various insecticides might result in synergistic interactions is unknown. The health effects observed following exposure to a given insecticide are often similar to the other insecticides. Most of the health effects observed would be difficult to identify objectively or, because of a vague or slight effect, to document. Neurological effects observed in humans (from different routes of exposure and both acute and long-term exposures) include headache, dizziness, irritability, muscle tremors, confusion, convulsions, hyperexcitability, malaise, and anorexia. Additional effects following long-term exposure to dieldrin include memory loss, lack of coordination, and gonitis. Convulsions would be easier to document than some of the other effects. Generally, following cessation of exposure to a single insecticide, the neurotoxic

effects listed above are reversible. The rate of recovery varies depending upon the insecticide. Whether concurrent exposure to other insecticides would affect this reversibly is unknown.

Neurotoxic effects observed following inhalation of xylene by male subjects include short-term memory loss and decreased ability to handle numbers, body balance, manual coordination, and reach on time [36]. From the results of one study, adaption may occur following prolonged exposure, such that, the neurotoxic effects are reduced.

Arsenic exposure can result in peripheral neuropathy where both the sensory and motor neurons are affected [1]. Recovery is slow and often incomplete. In addition, arsenic can increase the neurotoxic effects of lead in children (e.g., aggressive behavior and learning abilities) [1]. Although the children may not be exposed to elevated levels of lead when at the site, if they were exposed to lead elsewhere (e.g., in drinking water from lead pipes or solder, or lead paint at home), this outcome might be of concern. Both the children and the workers would have been at increased risk to the neurotoxic effects of the insecticides, xylenes, and arsenic from exposure to highly contaminated surface soils, solid and liquid wastes, fugitive dusts, and vapors.

* Hematotoxicity and immunotoxicity - Many of the chemicals detected on-site are known to be hematotoxic and/or immunotoxic. Impaired hematopoiesis (formation of the different blood cells) has been demonstrated in occupational studies of benzene, alpha- and gamma-BHC, and arsenic exposure [1]. Hematologic disorders observed are: (1) for benzene - pancytopenia and specific cytopenias, bone marrow depression, and leukemia; (2) for BHC - leukopenia, leukocytosis, granulocytopenia, granulocytosis, eosinophilia, monocytosis, thrombocytopenia, and hypochromic anemia; and (3) for arsenic - leukopenia, anemia, and eosinophilia. Some of the site-related contaminants are known or suspected of being associated with cancers of the immunologic and hematologic system, i.e., (1) arsenic has been suggested as being associated with cancers of the lymphatic tissues and leukemia [1]; (2) based on equivocal evidence, 2,4-D has been associated with non-Hodgkin's lymphoma [38,58,81,105]; (3) lesser evidence for 2,4,5-T has suggested an association with non-Hodgkin's lymphoma and, perhaps, Hodgkin's disease [1,35] although the data for both diseases are equivocal; (4) benzene is a known human leukemogen

causing acute myelogenous leukemia (AML) and has been suggested to be associated with other leukemias, non-Hodgkin's lymphoma, and Hodgkin's disease [1]; and (5) creosote has been suggested to be associated with non-Hodgkin's lymphoma [91]. Except for benzene and AML, the evidence is inconclusive at this time. Other disorders that might be outcomes, at least in part, of hematotoxicity are other cancers and infections, immune disorders, and susceptibility to bleeding. Some occupational studies of exposure to benzene have indicated autoimmunity and allergy as effects [1]. Studies with animals have indicated that the following compounds may impair the immune system: chlordane, DDT, dieldrin, BHC, 2,3,7,8-TCDD, benzene, and tetrachloroethylene [1]. What synergistic effects exposure to a mix of these chemicals would have on immunotoxicity and hemato-toxicity are unknown. The relative contribution by benzene, BHC, and tetrachloroethylene are probably less than for the other contaminants listed above, because they are present on-site less frequently and at lower concentrations; however, they may contribute to the overall risk of immunotoxicity and hemato-toxicity. The workers and children are both at risk to these effects from exposure to surface soils, solid and liquid wastes, fugitive dusts, and vapors.

Hemolytic anemia is known to occur in humans following oral, inhalation, dermal, and transplacental exposure to naphthalene [35]. Individuals susceptible to hemolytic anemia from naphthalene exposure are those individuals deficient in certain erythrocyte enzymes, such as, pyruvate kinase and glucose-6-phosphate dehydrogenase (G-6-PD). Because G-6-PD deficiency is an X-linked, recessive trait, males express this disorder more often that do females [82]. The prevalence of this inherited trait for particular populations is about 16% of U.S. Blacks, 12-13% of Filipinos, and 11% of Mediterranean Jews [62]. The severity of the deficiency varies between the populations. Reduction of NADP (and also GSSG) does not readily occur, thus, resulting in depletion of GSH, oxidation of hemoglobin, and hemolysis. Development of hemolytic anemia can occur 12 hours to 1 week following exposure [82]. Infants appear to be particularly susceptible to developing hemolytic anemia.

Exposure to methylarsine and, especially, arsine would increase the risk of developing hemolytic anemia [1]. Both compounds act by depleting GSH, and causing the oxidation of hemoglobin and hemolysis. Whether individuals with an erythrocyte enzyme deficiency are

particularly susceptible to arsine- and methylarsine-induced hemolytic anemia is unknown, but appears probable. Symptoms from naphthalene and arsine toxicity are the same, i.e., jaundice, anemia, and renal damage [1,82].

Exposure to naphthalene readily occurred to the workers and, probably, to the children. Specific monitoring for arsine and methylarsine has not been conducted. Substantial exposure to methylarsine and arsine is less likely to have occurred, because these compounds are formed from microbial action on arsenic in wetland areas, and, although volatile, would tend to be released only under certain atmospheric or climatic conditions. The hemolytic effects from arsine and methylarsine exposure are more of a concern during excavation of the wetlands for remediation.

* Hepatotoxic effects - Various contaminants (chlordane, DDT, dieldrin, and ethylbenzene) found on-site are known from animal studies to induce the hepatic microsomal enzymes [1,36]. Induction of enzymes might result in increased metabolism of xenobiotics to toxic (or less toxic) metabolites, thus, increased hepatotoxicity or an increased susceptibility to cancer. The possible effects from enzyme induction are not known with certainty. Animal studies have demonstrated the hepatotoxic effects of dieldrin, BHC, trichloroethylene, and tetrachloroethylene [1]. Human studies indicate that 2,3,7,8-TCDD, vinyl chloride, trichloroethylene, tetrachloroethylene, xylenes, and arsenic may be or are hepatotoxic [1,36]. The likelihood that hepatotoxic effects would occur to the workers and the children seems unlikely, because many of these chemicals are found at relatively low levels in the readily accessible environmental media. However, should an individual have a hepatic deficiency, that person may be susceptible to the hepatotoxic effects of these compounds.

* Decreased fertility and other reproductive effects - Very little information is available regarding the human reproductive effects of the site-related contaminants. Most of the available data originate from studies of animals. DDT, 2,4,5-T, and 2,3,7,8-TCDD appear to be reproductive toxins [1]. The reproductive toxicity of 2,4,5-T may be due, at least in part, to the presence of the strong reproductive toxin, 2,3,7,8-TCDD, as an impurity. The limited amount of human data is consistent with 2,4,5-T being a reproductive toxin. Long-term oral exposures of animals with DDT resulted in adverse reproductive

effects, such as, decreased fertility, lack of mammary gland development, delayed estrus, and reduced male libido. Shorter term exposures also resulted in reproductive effects to male and female animals. Occupational studies of humans exposed to DDT did not result in observed effects. Although the workers and the children were exposed to these chemicals present in the soils, waste water, solid waste, and fugitive dusts, enough information is not available regarding the reproductive toxicology of these chemicals to determine the possibility of an adverse effect.

* Developmental toxicity - As for reproductive effects, very little information is available regarding the human developmental toxicity of the site-related contaminants. Based on animal studies, developmental effects have been observed for chlordane, DDT, DDE, DDD, dieldrin (although maternal toxicity usually occurred), 2,3,7,8-TCDD, 2,4,5-T, 2,4-D, PAHs (with three or more aromatic rings [63]), naphthalene, and arsenic. Teratogenic effects were observed for 2,3,7,8-TCDD (e.g., cleft palate), 2,4,5-T (may be due, at least in part, to 2,3,7,8-TCDD impurities), and arsenic (often at maternally toxic doses) [1]. Neurobehavioral effects were observed in offspring of animals treated with 2,4,5-T/2,4-D, chlordane, and DDT (perinatal exposure - combined transplacental and maternal milk exposures) [1,82]. Delayed development was observed from gestational exposure to naphthalene (delayed cranial ossification and heart development) and DDT (delayed vaginal opening and slowed growth) [1,57,92]. For the insecticides, perinatal exposure often resulted in increased toxicity compared to prenatal exposure, and, at times, resulted in increased neonatal and preweaning mortality [1]. Other effects observed from perinatal exposure include depression of cell-mediated immunity (chlordane) and slowed physical development and effects on learning and memory (DDT) [1]. Cataracts and retinal damage were observed in offspring of rabbits treated with naphthalene, and is consistent with known cataract formation in humans following occupational exposure [35]. Hemolytic anemia has occurred to G-6-PD deficient humans from transplacental exposure to naphthalene [35]. The sex ratio of offspring increased for residents living near a smelter, and has been correlated with arsenic levels in the soil [102]. This sex ratio observation is supported by a limited amount of animal data [1].

Any synergistic association from exposure to a mix of these chemicals is unknown. In addition, the relevance of most of the results of the animal studies (except

cataracts and, perhaps, depression of cell- mediated immunity) to humans is unknown. Should a pregnant woman have worked at the facility or have accessed the site area, her child may have been at an increased risk of developmental toxicity. However, the overall population that would have experienced this risk is probably very small.

* Cancer - Numerous chemicals detected on-site are known or probable human carcinogens. Known human carcinogens based on occupational studies are benzene (acute myelogenous leukemia), vinyl chloride (liver angiosarcoma), and arsenic (multiplicative effect on the influence of smoking on developing lung cancer) [1,37]. Ingestion of arsenic in drinking water is known to cause skin cancer based on studies in Taiwan [37]. Although not supported by the results of studies in the United States, it is supported by studies from other countries. Other types of cancer have not been shown to be caused by exposure to these chemicals, but have been associated to varying extents, i.e., for benzene - other leukemias, Hodgkin's disease and non-Hodgkin's lymphoma; for vinyl chloride - brain, liver and digestive tract cancers; for occupational exposure to arsenic - liver cancer; and for ingestion of arsenic - liver, lung, and bladder cancers, and, to a lesser extent, mammary gland, nasopharynx, lymphatic, and kidney cancers and leukemia. Although a causal association has not been documented for ingestion of benzene or vinyl chloride, studies of oral exposures to animals indicate that these chemicals are carcinogenic from exposure by this route.

Other contaminants have been classified by EPA or IARC as probable human carcinogens based on the results of animal studies and/or limited epidemiologic evidence. These chemicals include chlordane, DDT, DDE, DDD, dieldrin, alpha- and gamma-BHC, trichloroethylene, tetrachloroethylene, creosote, and some of the PAHs [1,63,64]. Creosote has been classified by IARC as a probable human carcinogen [64]. Based on limited occupational studies, workers were observed to develop skin cancer, especially of the scrotum [64] and non-Hodgkin's lymphoma [91].

Other site-related contaminants have not been classified because of a lack of information or because the available information is inconclusive. Sufficient information does not exist for naphthalene [35], 2-methylnaphthalene, xylenes [36], 2,4-dimethylphenol (a dated study indicates that this compound may have promoter activity) [5,34], and ethylbenzene [35].

Stronger evidence exist for phenoxy acetic acids overall than for any individual herbicide. Inconclusive information is available for 2,4-D (occupational studies indicate there may be an association with development of non-Hodgkin's lymphoma and, to a lesser extent, soft tissue sarcoma [38,58,70,76,81] although other studies show no association) and 2,4,5-T (occupational studies indicate there may be an association with development of soft tissue sarcoma, and, perhaps, non-Hodgkin's lymphoma and Hodgkin's disease [1,16,18,35,38, 49-54,105,107] again some studies show no association). A limited amount of animal carcinogenicity studies exist. These studies are also inconclusive.

Other than the multiplicative effect of occupational arsenic exposure to the development of lung cancer by smokers, little information is available regarding the synergistic effect of exposures to multiple substances relative to the site on the development of cancer [1]. A number of the contaminants have been shown to be causally related to, associated with, or implicated with cancers of specific organs or systems.

In particular, several of the contaminants are known or suspected of an association with cancers of the immune and hematologic systems. Leukemia has occurred following occupational exposure to benzene and has been implicated with ingestion of arsenic-contaminated drinking water. Non-Hodgkin's lymphoma has been associated to varying certainty with occupational exposures to 2,4-D, creosote, benzene, and 2,4,5-T, and arsenic. Less evidence is available for Hodgkin's disease from exposures to benzene and perhaps 2,4,5-T.

The cancers of the hematological system have been associated with various risk factors. Immunodeficiency appears to be a common risk factor, and may play an etiologic role in the development of these cancers. For example, primary, acquired, and therapeutic immunodeficiency disorders have been shown to increase the risk of developing non-Hodgkin's lymphoma [99]. The risk of developing non-Hodgkin's lymphoma is particularly high if chronic antigenic stimulation occurs together with depression of suppressor cell activity [99]. Site-related contaminants known to impair the immunohematopoietic system or to depress immunity include chlordane, DDT, dieldrin, BHC, 2,3,7,8-TCDD, benzene, and arsenic. Whether the chemicals affecting immunity and those chemicals implicated in hematologic cancers interact in a synergistic manner to increase the risk of developing

leukemia, non-Hodgkin's lymphoma, or Hodgkin's disease is unknown.

Other cancers for which more than one site-related contaminant has been associated are skin cancer (ingestion of arsenic and occupational exposure to creosote), soft tissue sarcoma (2,4-D and 2,4,5-T), and liver cancer (occupational exposures to vinyl chloride and arsenic and ingestion of arsenic).

Past exposures to the children and workers at the site may have increased their risk of developing cancer. The contribution of the volatile organic contaminants to this risk is uncertain because the detected levels are low in the surface soils and surface water, and if past exposures to volatile organic contaminants were elevated from contact with wastewater or creosote is unknown. It is unknown if vinyl chloride was ever actually used at the BMCCI facility, or if its presence in the ground water is due to degradation of other chlorinated volatile organic compounds. If never used, the health impact to the workers and children from exposure to vinyl chloride is unlikely.

* Bioaccumulation - Bioaccumulation indicates if a body burden of the chemicals of concern might persist. This information can be an aid in determining if continued toxic implications might exist and whether or not an exposed population could be identified. Some of the insecticides, especially DDT and its metabolites, chlordane, dieldrin and BHC, and 2,3,7,8-TCDD tend to bioaccumulate in the adipose tissue [1]. Elevated body fat or serum levels of these compounds in workers or children who played near the site might document that exposure occurred. If DDT, its metabolites, and chlordane were detected at the highest levels of the chemicals found in serum or body fat, it could be indicative of site-related exposures.

  However, it is important to note that exposures to the workers and children ceased around 1982 or 1983. The half-lives of these compounds in adipose tissue are unknown. Whether appreciable levels might exist in individuals seven or eight years later or would be near background (i.e., typical for the unexposed U.S. population) levels is unknown. Prolonged, elevated levels of these compounds in the body might have an effect of chronic health disorders or development of diseases that take longer to manifest.

Present - Because of the past interim remedial activities, exposure to the site contaminants would be to the occasional

person accessing the site and the dose of exposure would be low. For these reasons, an adverse health impact resulting from current exposure is unlikely.

Future - If proper precautions are not taken, adverse health effects may occur from remediation activities and following remediation; however, measures will be implemented during remediation to minimize exposures. The populations most likely to be impacted are the remedial workers, workers at the industries close by, and nearby residents. Remedial workers, without the proper personal safeguards, could be exposed to the contaminants present in any of the environmental media by a variety of exposure routes. In particular, excavation of soils could result in the volatilization of contaminants (including naphthalene) located in the subsurface soils and ground water, and excavation of wetland areas could result in the release of arsine or methylarsines. Naphthalene, methylarsines, and arsine exposures (inhalation mostly, but also dermal contact and ingestion) could result in hemolytic anemia in susceptible individuals (e.g., pyruvate kinase or G-6-PD deficient). Because arsine and methylarsines are oxidized to nonvolatile forms once exposed to the atmosphere [1], exposure and resulting health impact are relatively unlikely in off-site areas.

Workers at nearby industries could be exposed to fugitive dusts, vapors, and small-sized particulates during remediation. Without the proper safeguards (e.g., engineering controls and appropriate action levels), these workers may be at risk of adverse health effects.

If proper emission controls are not used during destruction of contamination in soils, nearby residents may be exposed to small-sized particulates (<10 um). These particulates could evade the filtering mechanism of the nasal passage and be drawn into the bronchial passages, even for individuals living or working a distance from the site. Except for arsenic, the contaminants that would be present in the particulates are unknown. Exposure to arsenic by inhalation would increase the risk of lung cancer, especially to residents who smoke [1]. The maximum stack emission level for arsenic was chosen following a conservative protocol and should be protective of public health. Proper worker safety precautions, remediation design and operation, and excavation procedures would minimize the health impact to workers and other people. The EPA will develop a site safety and health plan for all stages of remediation.

2. The Cochato River

Past, Present, and Future - Health effects resulting from exposure to site-related contaminants found in the Cochato River's sediment, fish, and surface water would likely occur mostly to individuals fishing in the river and its associated water bodies (Sylvan Lake and the ice pond) and to children playing/wading in the river and its associated wetland areas and water bodies. Except for the past, when creosote would discharge into the river and prior to the installation of the ground water recirculation system, health effects stemming from exposure (dermal contact, incidental ingestion, and inhalation of volatile contaminants originating from the river) to surface water are unlikely. Past exposure to creosote, low molecular weight PAH's (mostly naphthalene and 2-methylnaphthalene), and volatile organic compounds could have resulted in an increased risk of hemolytic anemia to susceptible individuals [35] and of cancer [1,62,64].

Past and current exposure to sediments along the stretch of the Cochato River to around Sylvan Lake could result in an increased risk of developing cancer from dermal contact and incidental ingestion. Compounds of most concern are PAH's, arsenic, DDT and its metabolites, chlordane, and dieldrin. Monitoring information was insufficient for the stretch of the Cochato River from Sylvan Lake to the ice pond to assess the health risk. However, except for where bends in the river are located, the deposition of sediments in this area is less likely than in the ice pond located upstream of this stretch. Occasional contact with ice pond sediment is less likely to be of health concern than contact with river sediment upstream of Sylvan Lake.

During remediation, exposure to sediment contaminants could be of concern to the remediation workers, if personal safeguards are not followed. Health effects of concern are hemolytic anemia and, long-term, cancer. Following remediation, health effects stemming from future exposure to sediments are less likely. Because remediation will not totally remove the contaminants from the ground water and because arsenic-contaminated remediation by-product will be backfilled into the nearby excavation areas, continued production of contaminated sediment will result. Whether or not the contaminant levels will become a health concern remains unknown. If exposure from future dredging of the river and disposal of the sediment (to workers involved in the dredging of the sediment and to people, particularly children, near the disposal area) would constitute a health concern remains unknown, because the available sediment monitoring data are insufficient to characterize the contamination downstream of the Sylvan Lake inlet (except for the ice pond). Sediment monitoring is planned during

remediation, and this information could be used to determine the level of health concern.

Past, present, and future exposures to fish would occur to the recreational fishermen and their families. The health impact stemming from this exposure cannot be determined because of (1) the limited amount of monitoring data, particularly in the water bodies where fishing is most likely to occur (Sylvan Lake and the ice pond), and (2) the lack of information pertaining to the use of the fishery. The number of people using the fishery and whether a small, subpopulation exists that obtains a significant portion of its protein supply from this water system are unknown. The contaminants of concern are 2,3,7,8-TCDD, DDT and its metabolites, chlordane, and PAH's including naphthalene and 2-methylnaphthalene. Arsenic may be present at elevated levels in the fish. When present, arsenic is usually in relatively nontoxic forms (e.g., arsenobetaine and arsenocholine); however, the arsenic levels in the sediments are very high, and the proportion of each arsenic form can vary depending on fish species and environmental conditions [1]. Speciation of the arsenic in fish has not been done for the Cochato River. Although the amount of fish monitoring data is limited, a review of that data indicates that an elevated risk of cancer may result depending upon the use of the fishery by an individual. Ingestion of contaminated fish might add to the health risk from exposure to sediment.

3. Water Supplies

Water supplies potentially impacted by the Baird and McGuire site are municipal drinking water sources (i.e., Great Pond Reservoir via the Richardi Reservoir and Cochato River, and South Street Wellfield) and private water supplies (industrial and domestic water supply wells).

Past, Present, and Future - Great Pond Reservoir - The Great Pond Reservoir system is a source of potable water for the towns of Holbrook, Randolph, and Braintree. Available evidence indicates that the Great Pond and Richardi Reservoirs were not affected by the site's contaminants; thus, an adverse health impact from exposure (ingestion or dermal contact) to site contaminants in the reservoir water is very unlikely. At this time, the sluice gate used to divert Cochato River water to the Richardi River is closed, and no health effect could result from current exposure via this route. Although the sediment contamination appears to be approaching the stretch of the Cochato River near the sluice gate, insufficient information is available to determine if an adverse health effect could result should the sluice gate be opened in the future. Because the

planned remediation does not address the contamination found in the sediments beyond the part of the Cochato River upstream of the Sylvan Lake, the downstream contamination (near the Richardi Reservoir) is expected to increase before decreasing.

Past, Present, and Future - private water supply wells - Information pertaining to domestic water supply locations were reported by the general public to the local Board of Health or Water Department. Other private wells may exist closer to the site. Based on the available information, it is unlikely that the known domestic wells have been, are, or will be impacted by the contaminated ground water originating from the site. Most of the contaminated ground water discharges into the Cochato River. The only uncertainty is for the bedrock wells that may exist in the area (little or no information is available with regard to well installation). Contaminated ground water transport within bedrock fissures is difficult to determine. The potential for a bedrock well to be impacted is slight, but does exist. In addition, ground water remediation does not address the contamination that may exist in deep bedrock. Because of this lack of information, the potential health impact would be difficult to assess, yet should be assumed to exist.

One industrial well is known to exist in the vicinity of this site. Although, volatile organic compounds have been detected in the water obtained from this well, it is unknown if this contamination originated from the site. Exposure to the workers could be via inhalation and dermal contact; however, insufficient information is available to assess the possible health impact in the past, at the present, and in the future.

Past, Present, and Future - South Street Wellfield - Past exposure to site-related contaminants occurred via use of water from the South Street Wellfield. Numerous uncertainties exist with regard to the contaminants present, the concentrations present, the duration of exposure, and the exact population affected. The contaminants and levels intercepted by the wellfield would vary with time depending upon what and how much contamination was released nearby and which wells were pumped. The percentage of South Street well water received at a residence would vary with time depending on (1) the interaction of supply and demand, (2) what other water supplies were being utilized and in what proportion, (3) whether the interconnections between the Randolph and Holbrook water distribution system were open, and (4) specific traits of each supply node in the water distribution system. Specific details regarding the

uncertainties are presented in the "Environmental Pathways" section.

Any of the site's contaminants, with the possible exception of 2,3,7,8-TCDD, could have been drawn into the wellfield and intercepted by the wells. Because of its exceedingly low water solubility and its ability to bind very tightly to soils [1], 2,3,7,8-TCDD was probably not drawn into the wellfield. In addition, no 2,3,7,8-TCDD was detected in that part of the site. The contaminants that are known to be associated with the wellfield (either in municipal well water, monitoring well water, or in the soils beneath the water table) are DDT, DDE, DDD, chlordane, dieldrin, naphthalene, 2-methylnaphthalene, other PAHs, arsenic, 2,4-D, "phenols", trans-1,2-dichloroethylene, benzene, trichloroethylene, and tetrachloroethylene. Other chemicals may have been present in the past, but have not been detected due to degradation or have already been flushed from the wellfield.

The populations most apt to be affected are the Grove area of Holbrook, and, perhaps, the Revere section of Holbrook and the part of Randolph closest to the South Street and Union Street interconnections (see the sections on "Environmental Pathways" and "Human Exposure Pathways" regarding the details and uncertainties). Two important considerations must be emphasized here. First, the children who were most apt to be affected from playing at the site probably drank municipal water that originated from the South Street Wellfield, and, thus, may be at the greatest potential risk of adverse health effects. Second, the population exposed to South Street well water is apt to include subpopulations of individuals susceptible to the toxic effects of the site-related contaminants (e.g., the elderly, individuals with immune and liver disorders, G-6-PD deficient individuals, individuals with chronic diseases, and the very young - fetuses, neonates, infants, and young children).

The potential health impacts would be nearly the same as for the populations exposed to the contaminants in the site/facility area. The following paragraph on possible health effects supplements or modifies the previous discussion regarding the facility/site and surrounding area. Most of the available toxicological data do not originate from studies of chronic oral ingestion by humans. Potential exposure is assumed to all site-related chemicals except 2,3,7,8-TCDD, methylarsines, arsines, and fish arsenic.

Possible adverse health effects are hemolytic anemia (human transplacental and oral exposures to naphthalene), cataracts (oral rabbit data supports occupational studies of

naphthalene), hyperkeratosis and hyperpigmentation of the skin from ingestion of arsenic [1,37],immunosuppression and immunohematopoietic dysfunction, neurotoxicity [convulsions and other disorders, especially (1) aggravation of aggressive behavior and learning disorders caused by simultaneous exposure to arsenic and lead to young children, and (2) the possibility of learning and memory disorders following transplacental exposure and exposure from mother's milk to insecticides as based on animal studies [1], toxic hepatitis and hepatic cirrhosis, perhaps decreased fertility and developmental effects (the overall population that may have experienced this risk would be appreciably larger than the population exposed to the contaminants at the site), vascular system effects (such as gangrene, arterial thickening, etc. from exposure to arsenic and, perhaps, vinyl chloride [1,37]), and cancer (especially skin cancer, non-Hodgkin's lymphoma, leukemia, soft tissue sarcoma, Hodgkin's disease, lung cancer, liver cancer, and bladder cancer). The fetus, neonate, infant, and young child are particularly susceptible to neurotoxic effects because of developing or maturing nervous systems. The reversibility of these effects are unknown. Bioaccumulation of the insecticides (DDT and its metabolites, chlordane, and, perhaps, dieldrin and BHC) may have occurred in the body fat of the population who drank South Street well water. Should a disproportionate amount of these insecticides still be present in the body fat and, perhaps, serum of these individuals, identification of the exposed population might be possible. See the previous discussion regarding the facility/site and surrounding area and bioaccumulation in workers and children.

Because the South Street wellfield is not being used at this time, the possibility for adverse health effects from current exposure does not exist. Should the wellfield be used in the future, adverse health effects may result since the currently proposed remediation does not address all the contamination at the site. Some contaminated ground water will remain, especially in the deeper part of the aquifer, and parts of the wetland areas either will not be remediated because contaminant levels are low or will be backfilled with arsenic-containing remediation by-product. However, the remediation plan entails the solidification of the by-product to reduce contaminant mobility. The potential for health effects may exist, but should be greatly reduced from past potential.

B. Health Outcome Data Evaluations

1. Existing Health Studies

Three previous health studies exist. Two descriptive studies were conducted by the DPH and used existing health statistics data. The first study is of cancer mortality and incidence in Holbrook [78]. The second study was of adverse birth outcomes in Holbrook and six surrounding communities including Randolph [79]. Both studies were conducted as a direct result of community concerns stemming from the Baird and McGuire site.

A third study was conducted by investigators from the Harvard School of Public Health [20]. This investigation was a cancer case study of the Bartlett-Green Acres neighborhood located in Randolph, and was conducted due to the perception of the neighborhood's residents that cancer incidence was elevated. This neighborhood is located near the Upper Reservoir of the Great Pond, and is more than one and one-half miles from the Baird and McGuire site.

Each of the studies is discussed briefly below. The presentation is based on chronological occurrence.

Epidemiologic Analysis: Holbrook [76] - Standardized Mortality Ratios (SMRs) and Standardized Incidence Ratios (SIRs) were calculated for total cancers and for the 12 primary cancers (i.e., stomach; calorically; liver; pancreas; bronchus and lung; breast; cervix; other female; prostate; bladder; kidney; and leukemia). SMRs were calculated for three five-year time periods (i.e., 1969-1973; 1974-1978; and 1979-1983). With the exception of the last time period, no significant increases in SMR's were observed for any type of cancer or for total cancer. For the period 1979-1983, significant increases ($p<0.05$) were observed of bronchus and lung cancer in males (24 observed, 15.1 expected, SMR 159), bladder cancer in males (5 observed, 1.5 expected, SMR 334), and other female cancer (7 observed, 3.1 expected, SMR 224). The primary risk factor for cancer of the bronchus and lung is cigarette smoking, but occupational exposures may play a role. The numbers of cases of bladder cancer and of other female cancers are small, and a determination of an environmental association with these cancers would be difficult to accomplish.

SIRs were determined for the period 1982-1983. The DPH's Cancer Registry was established in 1982. At the time of this report (1984), data for 1982 and 1983 were available. For the town of Holbrook as a whole, SIR's were not significantly elevated for total cancer and for the twelve primary cancers. SIRs for total cancer were calculated for the two Holbrook census tracts, and were not found to be significantly elevated. The cancer incidence cases were plotted on a map. No obvious clustering of cases was observed to occur near the Baird and McGuire site.

An Epidemiologic Investigation of Adverse Birth Outcome Data for Holbrook and Surrounding Communities: 1980-1984 [79]. Adverse birth outcome data available at the DPH were examined for the communities of Holbrook, Abington, Avon, Braintree, Brockton, Randolph, and Weymouth. Of these communities, Holbrook, Randolph, and, perhaps, Braintree are most apt to have outcomes related to the Baird and McGuire site. Outcomes considered were congenital anomalies, fetal deaths (gestational age of 20 weeks or more or body weight of 350 grams or more), neonatal deaths (within 28 days of birth), infant deaths (within 365 days of birth), and low birth weight. Although congenital anomalies and fetal deaths are considered under reported, this factor applies to the state and the nation, and is not specific to these communities. Rates were calculated for the period 1980-1984. The following excerpt from the report describes the findings:

> "No statistically significant elevations in the rate of congenital anomalies, fetal, neonatal, or infant deaths were observed for Holbrook or the surrounding towns. For Brockton, however, more infants of low birth weight were born than expected; this finding was statistically significant. A plotof fetal, neonatal and infant deaths did not reveal any unusual geographic clustering in the census tracts surrounding the Baird and McGuire site. No time-related clustering of adverse pregnancy outcomes was seen."

The outcome observed for Brockton is probably not related to the site.

An Investigation of a Reported Cancer Cluster in Randolph, Massachusetts [20]. This report presents a case study of cancer occurrence in the Bartlett-Green Acres (BGA) neighborhood of Randolph during the period 1964-1984. Although not in the Randolph census tract located closest to the Baird and McGuire site, residents of BGA expressed concern regarding the site because the Cochato River, into which the site drains, was used to recharge a reservoir serving as a source of drinking water. Analyses made were: calculation of expected cancer incidence; identification of incident cases; analysis of cancer registry cases; analysis of death certificates; total incidence; incidence by site; duration of residence; analysis of multiple-case households; spatial clustering; and investigation of sources of environmental exposure. The report abstract summarizes the findings of the study as follows:"From a list of names compiled prior to and during the investigation, 45 incident cases of cancer were identified and found suitable for analysis. An additional four cases of cancer were added from the Massachusetts Cancer Registry.

The analysis showed the existence of a cancer cluster, but overall cancer incidence and mortality in the BGA neighborhood were not elevated. Residence history, disease site, and other features of the cancer cases were investigated using methods less sensitive to incomplete reporting than total incidence. No unusual features of the cancer data other than the initiating cluster were identified and no environmental hazard likely to impact the BGA neighborhood was discovered, hence we conclude that the most likely cause of the cancer cluster was random variation in cancer rates."

2. Current Descriptive Health Study

As part of the Public Health Assessment prepared on behalf of the Agency for Toxic Substances and Disease Registry through the Massachusetts Demonstration Program, the Community Assessment Unit of the Massachusetts Department of Public Health (MDPH) updated a previous investigation [78] conducted by the MDPH. Standardized Incidence Ratios (SIRs) were calculated for the five year period 1982-1986 for the towns of Holbrook and Randolph. SIRs were calculated for cancers of the stomach, liver, pancreas, lung, hematopoietic/reticuloendothelial systems (i.e., leukemias and multiple myelomas), bladder and kidney. Hodgkin's disease, non-Hodgkin's lymphoma (NHL), soft tissue sarcoma, adrenal cancer, brain cancer, and malignant melanoma were also included in the analysis due to citizen concern over suspected elevations in these types of cancer or because the scientific literature indicates that these cancers may be associated with some of the contaminants detected at the Baird and McGuire site.

For the purpose of this assessment particular emphasis was placed upon the area around the Baird and McGuire site which is located in census tract (CT) 4211 in Holbrook and bordered by CT 4203 in Randolph. Accompanying tables are located in Appendix D.

Methods - Cancer incidence data for the years 1982-1986 were obtained for each town from the Massachusetts Cancer Registry of the MDPH Bureau of Health Statistics, Research and Evaluation. In order to determine whether an elevated rate of cancer exists in either Holbrook or Randolph, the two census tracts closest to the Baird and McGuire site, or the two census tracts combined, cancer incidence data were analyzed to compare the actual (or observed) number of cancer cases to the number that would have been expected based on the statewide cancer incidence experience. Standardized Incidence Ratios (SIRs) were calculated using 1980 population data (the most recent census year) obtained from the U.S. Federal Census Bureau [104].

The ratio of the observed number of cases to the expected number of cases is called the Standardized Incidence Ratio (SIR). An SIR equal to 100 indicates that the number of cancer cases in an area is equal to what would have been expected based on the statewide cancer incidence experience. An SIR of greater than 100 indicates that more cancer cases occurred than expected, and accordingly, an SIR of less than 100 means that fewer cases occurred than were expected.

Care should be taken when interpreting the SIR since one must take into account not only how large it is but also how stable it is. An SIR of 200 based on 3 expected cases and 6 observed cases is certainly large, but may be due essentially to 1 or 2 chance cases occurring from natural variation in the pattern of cancer incidence. In contrast, an SIR of 200 based on 300 expected cases and 600 observed has the same magnitude as the previous SIR but it is very stable. It is quite unlikely that 300 excess cases would occur by chance alone.

A standard statistical test (chi-square or poisson) was used to determine the stability or statistical significance of the SIR when five (5) or more cases were observed. A significant difference between the actual number of cases and the expected number of cases means that the difference is probably not due to chance. Statistical significance was determined using a one-sided p value. Two common cutoff points for statistical significance are probability values of less than 0.05 ($p<0.05$) or less than 0.01 ($p<0.01$). This means that the probability that the difference between the observed number and the expected number was due to chance is less than 5 chances in 100 (when $p<0.05$) or less than 1 chance in one hundred (when $p<0.01$). 95% Confidence Intervals were also calculated around the SIRs. The Confidence Interval provides an idea of the magnitude of the effect and the variability of the estimate.

Place of residence at the time of diagnosis was examined for each case to assess any possible geographic clustering of cases. The available occupational information and smoking status of each case was also evaluated. Residential and occupational histories were compiled for all NHL cases in Holbrook and Randolph due to observations made in preliminary analyses. This was accomplished through the use of voter registration listings and annual resident's lists for the two towns [60,94].

Results - Overall, for males and females combined, cancer incidence in the town of Holbrook was about what would be expected based on Massachusetts statewide cancer incidence rates. Slight elevations were observed in cancers of the pancreas, hematopoietic/reticuloendothelial systems, and

kidney. These elevations were due to excesses of 1 or 2 cases occurring and were not statistically significant. A significant elevation was observed in lung cancer (44 cases observed/29.5 cases expected, SIR=149, $p<0.01$).

Males in the town of Holbrook experienced cancer of the bladder and kidney slightly more often than expected. A statistically significant elevation, however, was observed among males for lung cancer incidence (31 cases observed/19.4 cases expected, SIR=159, $p<0.01$).

Females experienced slight elevations in cancers of the pancreas, lung, hematopoietic/reticuloendothelial systems, and kidney. These elevations were also due essentially to 1 or 2 excess cases occurring. None of the elevations observed were statistically significant. A borderline statistically significant elevation among females was observed in NHL (7 cases observed/3.4 cases expected, SIR=209, $p=0.058$). These data are summarized in Table D-1.

In the town of Randolph, again cancer incidence among males and females combined was essentially what would be expected based upon statewide rates. A statistically significant elevation was revealed among lung cancers (112 cases observed/92.0 cases expected, SIR=122, $p<0.05$). An elevation was observed among NHL (30 cases observed/21.4 cases expected, SIR=140, $p=0.046$). This result should be viewed with uncertainty since the confidence interval includes 100.

Males in Randolph experienced slight elevations in cancers of the stomach, lung, bladder and NHL. These elevations were not statistically significant. A statistically significant elevation was observed among male kidney cancers (16 cases observed/8.9 cases expected, SIR=180, $p<0.05$).

Females in Randolph experienced a statistically significant elevation among lung cancers (46 cases observed/32.7 cases expected, SIR=141, $p<0.05$). Elevations were observed in the incidence of stomach, pancreatic and bladder cancers as well as NHL and Hodgkin's disease; however, none of the elevations observed were statistically significant. There were no adrenal cancer cases reported for either Holbrook or Randolph during the period 1982-1986. (See Table D-2).

Census Tract Analysis:

Cancer incidence rates in census tract (CT) 4211 in Holbrook (bordering the Baird and McGuire site), among males and females combined, was essentially what would be expected based on statewide rates. Cancers of the lung and kidney occurred more often than expected overall and among males.

These elevations were statistically significant. NHL was statistically significantly elevated among females (5 cases observed/1.5 cases expected, SIR=333, $p<0.05$). Elevations in one or both sexes were also observed in cancers of the pancreas, bladder, brain, soft tissue sarcoma, and hematopoietic/reticuloendothelial systems. It should be noted that these elevations were based on excesses of less than one case and are not statistically significant. (See Table D-3).

For the most part cancer incidence for males and females combined in CT 4203 in Randolph was also essentially what would be expected based on statewide rates. Cancers of the pancreas, lung, bladder, and kidney as well as malignant melanoma occurred slightly more often than expected; however, none of the elevations observed were statistically significant. A statistically significant elevation was observed in NHL (17 cases observed/10.2 cases expected, SIR=167, $p=0.032$). Again, this result should be interpreted with caution since the confidence interval includes 100. A significant elevation was also observed in male bladder cancer (16 cases observed/9.2 cases expected, SIR=174, $p<0.05$). Elevations in lung, NHL, and hematopoietic/reticuloendothelial systems incidence were observed among males. Again, these elevations were not statistically significant. An elevation of borderline statistical significance was noted in male kidney cancer incidence (8 cases observed/4.1 cases expected, SIR=196).

Cancers of the stomach, pancreas and lung as well as malignant melanoma occurred more often than expected among females; however, the elevations observed were not statistically significant. An elevation was observed in female NHL incidence (9 cases observed/4.9 cases expected, SIR=181). This elevation was of borderline statistical significance ($p=0.062$). These data are summarized in Table D-4.

Perhaps the most striking result of these analyses is the elevations observed in NHL in both CT 4211 and CT 4203 among female cases. It is important to note that CT 4212 in Holbrook as well as CT 4201 and CT 4202 in Randolph did not reveal a significant increase. For males, NHL incidence was elevated in CT 4202 and CT 4203, but not to statistical significance. No cases of NHL were observed among males in Holbrook.

When the two census tracts (CT 4211 and CT 4203) are combined, the elevations in total NHL incidence become more pronounced than either census tract alone; however, the excess in female NHL largely explains this. Statistically significant elevations were revealed overall (22 cases

observed/13.4 cases expected, SIR=165, $p<0.05$) and among females (14 cases observed/ 6.5 cases expected, SIR=216, $p<0.01$). Males, however, only reveal a slight elevation (8 cases observed/6.9 expected, SIR=116). This elevation was not statistically significant.

The increase in NHL incidence remained consistent among total females in the town of Holbrook (7 cases observed/3.4 cases expected, SIR=209) and among males and females combined in the town of Randolph (30 cases observed/21.4 cases expected, SIR=140). NHL incidence among females and males separately in the town of Randolph also were elevated, but not at statistical significance. There were no male cases observed in the town of Holbrook. These data are summarized in Tables D-5 and D-6.

Residence:

Due to the observed elevations of lung cancer and NHL cases, place of residence at the time of diagnosis was examined for both towns. Analysis of the geographical distribution of lung cancer incidence reveals that no apparent clustering of cases exists in either Holbrook or Randolph. However, even though the cases appear fairly evenly distributed throughout the two towns, the amount of cases in CT 4211 and CT 4203 is more pronounced than in any of the other census tracts within Holbrook or Randolph.

Analysis of the residential histories of NHL cases in CT 4211 and 4203 reveal that the majority of cases were long time residents. However, the data for Randolph residents was incomplete. The town of Randolph only has complete data for the years 1964 through 1989. Whereas, the town of Holbrook contains data as far back as the year 1939. Seven of the twenty-two cases lived within approximately one mile of the Baird and McGuire site. Two of the cases, both males, in CT 4203 in the town of Randolph, who reside outside the 1 mile radius, lived within that radius prior to their date of diagnosis.

Smoking:

Smoking status was evaluated for each lung cancer case in the towns of Holbrook and Randolph as well as in CT 4211 and CT 4203. Since smoking is the leading cause of lung cancer, it is not surprising that the majority of lung cancer cases are current or former smokers. Of the individuals who reported a smoking status in the towns of Holbrook and Randolph, 93% (the number of individuals is one hundred twelve or n=112) reported a smoking status as current or former smoker, and 7% (n=9) reported a smoking status as

never smoked. Smoking status remained unknown for 22% (n=35) of the individuals.

In CT 4211, of the individuals who reported a smoking status, 94% (n=16) reported a smoking status as current or former smoker. Only one individual reported a smoking status as never smoked. Smoking status remained unknown for 35% (n=9) of the individuals. These results were fairly consistent in CT 4203. Smoking status analysis revealed that 93% (n=39) of the individuals reported a smoking status as current or former smoker and 7% (n=3) reported a smoking status as never smoked.

Analysis of the smoking status of bladder cancer cases in CT 4211 and CT 4203 revealed that 68% (n=15) of the individuals reported a smoking status as current or former smoker and only four (18%) of the individuals reported a smoking status as never smoked. Smoking status remained unknown for 14% of the individuals.

Analysis of the smoking status of kidney cancer cases in CT 4211 and 4203 revealed that 56% (n=9) of the individuals reported a smoking status as current or former smoker and only 25% (n=4) of the individuals reported a smoking status as never smoked. Smoking status remained unknown for 19% (n=3) of the individuals.

Occupation:

Review of the occupational data of lung cancer cases in Holbrook and Randolph did not allow the determination of what role, if any, occupation may have played in the development of lung cancers in Holbrook and Randolph. Review of the occupational data among bladder cancer cases revealed that 32% (n=7) of the individuals were employed in an occupation suspected of increasing the risk of developing bladder cancer. Occupational data remained unknown for 45% (n=10) of the individuals.

Occupational data among kidney cancer cases in CT 4211 and CT 4203 were incomplete. 50% (n=8) of the individuals reported an occupation as retired or unknown.

The review of occupational data among NHL cases revealed that of the 22 cases in CT 4211 and CT 4203, 55% were housewives or reported their occupation as "at home". Only 23% (5 individuals) are or were employed in an occupation suggested to increase the risk of developing NHL.

Discussion - Overall, with regard to the major cancer sites evaluated, the towns of Holbrook and Randolph do not appear to have an excessive rate of cancer. Standardized Incidence

Ratios reveal that in these areas cancer cases are occurring essentially as would be expected compared to statewide cancer incidence experience.

However, significant elevations were observed in total lung cancer incidence for Holbrook and Randolph, bladder cancer among males in CT 4203, kidney cancer in males in CT 4211 and CT 4203, and non-Hodgkin's lymphoma among females for the town of Holbrook, CT 4211, CT 4203 and these two CT's combined. There were no elevations observed in Hodgkin's disease, soft tissue sarcoma, brain cancer, adrenal cancer, or malignant melanoma.

Cancers, in general, have a variety of associated risk factors which are assumed to be related to the development of the disease. Many cancers are thought to be related largely to life-style habits such as cigarette smoking, diet, and alcohol consumption. Epidemiologic studies of both humans and laboratory animals have also related several cancers to adverse chemical exposures in the work place or in a person's environment. Other factors associated with the incidence of cancer are socioeconomic status, heredity/genetics, race and geography. Review of the scientific and medical literature has provided known or assumed risk factors for the cancers of interest.

Lung Cancer:

The major risk factor for lung cancer is cigarette smoking. The Federal Office of Smoking and Health estimates that in the United States, cigarette smoking accounts for approximately 95% of lung cancer deaths in males and approximately 80% of lung cancer deaths seen in females [109]. The analysis of smoking status among lung cancer cases in Holbrook and Randolph revealed that the majority of these individuals are current or former smokers.

Several occupational exposures have been associated with increased lung cancer incidence. These include occupational exposure to asbestos dust, chromium, polycyclic aromatic hydrocarbons, and arsenic [99]. Unfortunately, the lack of occupational data did not allow the determination of what role, if any, occupation may have played in the development of these cancers.

Bladder Cancer:

In general, the incidence of bladder cancer increases with age, occurring most commonly in the later years of life, usually around the age of sixty. Bladder cancer is more common in men than women. Cigarette smoking is the most important known risk factor for bladder cancer. Research

has indicated that cigarette smokers will develop cancer of the bladder two to three times more often than nonsmokers. It is estimated that 40% of bladder cancers among men are due to cigarette smoking [2]. Review of the bladder cancer cases in CT 4211 in Holbrook and CT 4203 in Randolph reveals that the majority of bladder cancer cases occurred between the ages of 65 and 84. Analysis of the smoking status of bladder cancer cases also revealed that the majority of individuals were current or former cigarette smokers.

A number of occupational exposures are also suspected to increase the risk of developing bladder cancer. These include workers in the rubber and leather industries, painters, chemical workers, printers, metal workers, hairdressers, machinists, and truck drivers. Benzidine and 2-naphthylamine (chemicals used in the dyestuffs industry) are known bladder carcinogens [99]. Of the twenty-two individuals diagnosed with bladder cancer in CT 4211 or CT 4203, approximately 32% (n=7) were employed in an occupation suspected of increasing the risk of bladder cancer. It appears that smoking and occupational exposures probably played a role in disease etiology among these individuals.

Kidney Cancer:

As with lung cancer, cigarette smoking is also the most well established risk factor for cancer of the kidneys. Incidence rates for kidney cancer are twice as high for men than for women. Cancer of the kidney occurs most commonly between the ages of 50 and 60 [2]. Elevated kidney cancer rates have been observed among those with an occupational exposure to asbestos. Obesity appears to play a role in females that have developed the disease. However, no definite relationship has been proven between viral, hormonal, or chemical carcinogenic factors and the development of cancer of the kidney [2].

Review of the kidney cancer cases in CT 4211 and CT 4203 revealed that the majority of cases occurred among males between the ages of 50 and 60. The lack of occupational data did not allow the determination of what role occupation may have played in the development of these cancers.

Non-Hodgkin's Lymphoma:

Lymphomas are not a single disease but represent a diverse group of malignancies. Lymphoma is a general term applied to neoplasms of the lymph node tissues. Non-Hodgkin's lymphomas are a group of lymphomas considered separately from Hodgkin's lymphoma (Hodgkin's disease) because they lack the unique cell type (Reed-Sternberg cell) present in individuals with Hodgkin's disease [99]. The incidence of

NHL increases with age, with a mean age of approximately 50 years. However, NHL can occur in individuals of all ages. NHL is generally more common in males than females [2].

Although there is no known single cause for NHL, it is thought to be associated with certain viruses and immunodeficiency diseases. Individuals who develop immunosuppression as a result of renal transplants appear to be at an increased risk of developing this disease [99].

Several occupational exposures have been suggested as increasing the risk of developing NHL. These include sales and clerical personnel, postal workers, real estate and insurance brokers, engineers, mechanics, machinists, metal workers, and farmers. Recent studies have suggested an association between the development of NHL and vinyl chloride workers, rubber workers, workers involved in petroleum refinery, processing of arsenic-containing ore, and the use of phenoxyacetic acid herbicides [99].

The development of NHL also appears to be influenced by socioeconomic factors, particularly social class, urbanization, and ethnicity. The risk of NHL appears to be greater among individuals of Jewish descent. The literature also suggests that a greater susceptibility of women with increasing age may be related to hormonal changes of lymphoid function later in life [99].

Conclusions - Many of the rates presented here are based on very small numbers of cases. Thus, it would be difficult to prove environmental associations with these types of cancer. One of the most interesting results of these analyses appears to be the elevation of lung cancer cases. Although the lung cancer elevations observed were statistically significant, one should exercise caution in the interpretation of these results. While the development of lung cancer has been associated with exposure to certain environmental contaminants, it is important to remember that the major risk factor for lung cancer is cigarette smoking and 93% of the lung cancer cases reported in the Holbrook/Randolph area were current or former smokers. Thus, it is likely that smoking played a major role.

Significant and borderline significant elevations do exist among non-Hodgkin's lymphoma cases, although the elevations were only among females. Non-Hodgkin's lymphoma incidence is elevated in the two census tracts combined that border the Baird and McGuire site, among females for Holbrook, combined males and females for Randolph, and among females in both CT's 4211 and 4203. Incidence was elevated among males in CT 4203 and CT 4202 in Randolph, although not statistically significantly. It is interesting to note that

no cases of NHL were observed among males in the town of Holbrook. Based upon the available occupational information, it is assumed that some of these individuals were potentially exposed in the workplace. It is also suggestive, based upon what is known about the environmental contaminants that were documented at the BMCCI, that environmental exposures could have played a role. What exact role is impossible to determine due to the lack of information on the extent of the contamination and the environmental fate and transport of these contaminants to the population of Holbrook and Randolph.

This investigation is descriptive in nature and can only provide an evaluation of certain types of cancer incidence in the Holbrook/Randolph area compared to cancer incidence in the state. Descriptive assessments have certain inherent limitations. Only routinely collected data are analyzed, and information regarding personal risk factors (such as, occupation, diet, smoking, etc.) that may influence disease incidence are often limited and are not of an historical nature.

It is beyond the scope of these analyses to determine the causal relationship and/or synergistic roles that occupation, smoking status, and/or environmental exposures may have played in the development of lung cancers and non-Hodgkin's lymphoma in this area but only to report our findings and discuss them in the context of available information. The Community Assessment Unit will work with appropriate local and federal officials, the residents of this area and the medical community to develop intervention strategies and/or to design appropriate follow up investigations.

C. Interpretation of Toxicological and Health Outcome Information

In this section, the potential toxicological implications from exposure to the site-related contaminants and results of the available health outcome studies are interpreted in relation to each other. In addition, community health concerns are described and a determination made as to whether this Public Health Assessment addresses those concerns.

The populations most apt to have exhibited or to exhibit the toxic effects of Baird and McGuire site contaminants are the workers at the facility, children who played at the facility, and consumers of the South Street wellfield municipal water supply. The available toxicological literature indicates the possibility (but not the actual occurrence) of the following adverse effects: chloracne (workers and children), cataracts, neurotoxicity (including convulsions, learning disabilities, aggressive

behavior, and memory loss), altered immunohematopoiesis and immunodeficiency, other hematotoxicities especially hemolytic anemia, cancer, developmental toxicity (drinking water consumers mostly), and, perhaps, reproductive toxicity and hepatotoxicity. Based on toxicological information and available epidemiological investigations (mostly occupational studies), the specific cancers of concern from exposure to Baird and McGuire site contaminants are non-Hodgkin's lymphoma, skin cancer, lung cancer, Hodgkin's disease, leukemia, soft tissue sarcoma, and, to lesser extents, liver cancer and bladder cancer.

Community concerns have been detailed previously. Health concerns expressed include the diagnosis of serious diseases in eight young adults, who played on the site as children and likely drank water that originated from the South Street wellfield. The diseases experienced were three cases of Hodgkin's disease, and one case each of leukemia, melanoma, brain tumor, adrenal cancer, and sarcoidosis (a disease associated with immunodeficiency). Other health concerns alleged to be associated with playing near the site are chronic endocrine problems and weakened immune system. Nearby residents report a perceived increase in cancer and reproductive problems (miscarriages, sterility, and birth defects).

The two most relevant health studies are the current descriptive cancer incidence study of the Holbrook and Randolph census tracts (1982-1986) and the descriptive adverse birth outcome investigation for Holbrook, Randolph, and surrounding communities (1980-1984). The current descriptive cancer incidence study did not report any increase in the overall cancer rates for the towns of Holbrook and Randolph or for the two census tracts located closest to the site (i.e., CT 4211 in Holbrook and CT 4203 in Randolph). However, this may be due to an overall dilutive effect because the number of people with cancer is small and only some primary sites would be expected to be in excess, given what is known about the risk factors among cases. This descriptive study examined incidence rates for all the cancers listed above as being of concern (from community concerns and based on toxicological implications), except for skin cancer. With the exception of malignant melanoma, skin cancers are not reported to the Cancer Registry and, therefore, only rates for malignant melanoma can be analyzed. For the two census tracts of concern, statistically significant increases were observed of lung cancer in males (CT 4211), bladder cancer in males (CT 4211 and 4203), NHL in females (CT 4211, CT 4203, and CT 4211/CT 4203 combined), and kidney cancer in males (CT 4203). Statistically significant elevations were not reported for the other cancer types.

Occupational exposures and cigarette smoking are risk factors for cancers of the lung, bladder, and kidney. For the lung and bladder cancer cases that reported smoking status, most cases are former or current smokers. About one-third of the bladder cancer

cases reported occupations that are suspected of elevating the risk of bladder cancer. Life-style factors appear to have played a major role in the etiology of lung and bladder cancers in males. Whether the contaminants from the site had a role in the elevated rates of either of these cancers is uncertain.

Organic contamination in soils will be destroyed. The by-product may contain arsenic. If proper control measures are not taken, inhalation of arsenic-containing particulates by smokers living or working nearby may result in an increase risk of lung cancer. However, the maximum stack emission level for arsenic was chosen using conservative criteria, and should reduce this risk. Exposure to arsenic has a multiplicative effect on the development of lung cancer by cigarette smokers. It appears that the towns of Holbrook and Randolph have a disproportionate number of smokers, since lung cancer rates are already elevated for CT 4211 and for the towns of Holbrook and Randolph, and the majority of the lung cancer cases were current or former smokers.

NHL incidence in females is significantly elevated in the two censuses tracts near the site. When the two census tracts are combined the statistical significance is especially apparent ($p<0.01$). Whether this elevation is associated with exposure to Baird and McGuire contaminants cannot be determined based on the information available at this time. However, several observations can be made.

1. Elevated rates of non-Hodgkin's lymphoma were observed in the two census tracts located closest to the site, and are most apt to have received drinking water from the South Street wellfield and/or suffered synergistic exposures resulting from contact with the site. The remaining one Holbrook census tract and two Randolph census tracts did not have significantly elevated rates of NHL.

   Limitations: The actual distribution of the South Street well water is unknown. However, areas of CT 4211 certainly did receive water from the South Street wellfield and, even though the CT 4211 has a smaller population size, this census tract had a more significant elevation in NHL than did the Randolph census tract. Whether any of these cases played or worked near the facility, which may have increased the potential "dose" of exposure, is unknown.

2. A number of Baird and McGuire contaminants have been associated, to varying certainty, with non-Hodgkin's lymphoma based on occupational studies (i.e., 2,4-D, 2,4,5-T, and benzene and creosote and arsenic). In addition, a number of site-related chemicals are known to affect the immune system (i.e., chlordane, DDT, dieldrin, BHC, 2,3,7,8-TCDD, benzene, and arsenic). Immunodeficiency, especially when chronic antigenic stimulation occurs

together with depression of suppressor cell activity, appears to be a risk factor for development of NHL.

Limitations: A causal relationship between exposure to any of these chemicals and development of NHL has not been determined. In addition, the carcinogenicity of 2,4-D and 2,4,5-T has not been established because of equivocal evidence although two recent studies support their carcinogenicity. Most of the associations are based on occupational studies. The elevations are experienced by females, who were less likely to have been exposed to Baird and McGuire contaminants in an occupational setting.

3. A limited amount of monitoring data indicated the presence of DDT, chlordane, arsenic, 2,4-D, dieldrin, benzene, etc. in the South Street wellfield. In addition, based on the result of a model where all three South Street wells were pumped simultaneously, the wells may have diverted contaminated ground water from beneath the Baird and McGuire property.

   Limitations: The exact chemicals intercepted by the wells are unknown as are the time period each chemical was intercepted and the concentration delivered to the distribution system. However, a minimal amount of monitoring of the South Street wells indicated the presence of "phenols" as early as 1959, and of volatile organic compounds in 1980. No monitoring of acid, base/neutral extractable compounds, insecticides, herbicides, inorganic compounds, and certain volatile organic compounds was conducted of the South Street well water. No aquifer test to determine the zone of capture has been done. The modeling results are based on all three wells being pumped at the same time. Rarely did this occur.

4. Most of the non-Hodgkin's lymphoma cases were long-term residents of CT 4211 in Holbrook or CT 4203 in Randolph. In the two census tracts combined, for the cases where residential history could be determined, 15 of 19 cases lived in the census tract for at least 10 years prior to the date of diagnosis (1982-1986). The expected sex ratio for NHL incidence is 7:5 (male to female). When the two census tracts are combined the observed sex ratio is about 1:2 (6 male and 13 female) indicating a possible anomalous situation. CT 4211 in Holbrook had no male cases and 5 female cases. CT 4203 in Randolph had 6 male cases and 8 female cases (sex ratio = 3:4).

   Limitations: The latency period for development of NHL is unknown. The explanation for and the importance of the observed sex ratio are unknown as is whether the observed difference is of significance. However, from information

obtained during the search for residential histories, most of the female cases listed occupation as housewife or "at home" for some period of time prior to the date of diagnosis. If their drinking water originated from the South Street wellfield, they may have been exposed to more site-related contaminants in a variety of ways (e.g., cooking, cleaning, ingestion, etc.) than individuals who left the area during working hours. This possibility is conjecture at this time.

Eight young adults who played at the site as children were diagnosed with 5 types of cancer or sarcoidosis. Chronic endocrine problems and weakened immune system have been mentioned with regard to children who played near the site. The toxicological portion of this Public Health Assessment indicated that these individuals are probably at risk of immunodeficiency disorders and of developing cancer; however, this cannot be proven due to low statistical power. Sarcoidosis, Hodgkin's disease, and, perhaps, leukemia have been associated to some extent with immunodeficiency. Because of the occurrence of these types of cancers in the young adults, Hodgkin's disease, leukemia, adrenal cancer, brain cancer, and malignant melanoma incidence were examined in the current cancer incidence study. Statistically significant elevations were not reported for these cancer types. It should be noted, however, that these individuals are members of a small subpopulation who played on the site as children and may have experienced unique exposures when compared to other community members. This cancer incidence study does not specifically address this subpopulation, but, rather, includes all individuals who live in the census tracts.

Therefore, this study cannot assess whether an increased incidence of cancer exists for this subpopulation. Whether or not the occurrences of these diseases are a result of exposure to Baird and McGuire contaminants from playing at the site and drinking South Street well water cannot be determined in this Public Health Assessment nor is it likely that future investigations could establish true cause and effect due to the statistical limitations mentioned previously. Insufficient toxicological information exists pertaining to the effects of specific contaminants to the endocrine system to enable a determination of the possibility of an adverse endocrine outcome. No health study of the workers or the children who played at the site exists.

Based on the toxicological portion of this Public Health Assessment, the reproductive and developmental toxicities to which the community (mostly offspring) may be at risk are decreased fertility, neurobehavioral effects, delayed

physical and mental development, depressed cell-mediated immunity, cataract formation, and hemolytic anemia. The potential reproductive and developmental outcomes attributed to site contaminants are based mostly, but not exclusively, on animal data. The available birth outcome study examined the following parameters: fetal deaths, neonatal deaths, infant deaths, low birth weight, and congenital anomalies. This study utilized existing information and was conducted to determine whether an adverse situation was readily apparent. No adverse effects were observed in Randolph or Holbrook (based on whole town not census tract analysis); however, this study is not sensitive enough to detect the types of adverse outcomes potentially related to exposure to Baird and McGuire site contaminants. The community reported of a suspected increase in reproductive problems, such as, miscarriages, sterility, and birth defects. The birth outcome study may address the concerns regarding miscarriages and birth defects; however, because of a lack of more detailed information, no determination can be made. No community health concerns have been expressed nor health study has been conducted pertaining to the other potential toxicological effects not discussed in this section: chloracne, cataracts, neurotoxicity, hepatotoxicity, hemolytic anemia, and bioaccumulation of insecticides.

Conclusions

1. This site is judged to pose a public health hazard because humans have probably been exposed to hazardous substances at concentrations that may result in adverse human health effects. As noted in the Human Exposure Pathways Section above, human exposure (1) to contaminated South Street well water has probably occurred via ingestion, dermal contact and inhalation, and (2) to insecticides, herbicides, 2,3,7,8-TCDD, creosote constituents, and arsenic has probably occurred in the past via dermal absorption, incidental ingestion, and inhalation of contaminated soils, solid and liquid waste products, vapors, fugitive dusts, sediments, fish, seep water, and surface water. Possible current human exposures include ingestion and/or dermal contact to pesticides, polycyclic aromatic hydrocarbons, and arsenic in fish and sediments of the Cochato River.

2. Ingestion of contaminated water from the South Street wellfield is known to have occurred. The current cancer incidence study indicates an increased incidence of non-Hodgkin's lymphoma (NHL) for females residing in the census tracts supplied by the South Street wellfield. Although, based on the current data, no causal relationship can be established between the elevated incidence of NHL and ingestion of water from the South Street wellfield, this

possible relationship strongly supports the fact that this site poses a public health hazard.

3. The greatest exposure likely occurred to the workers at the facility and the children who played near the facility. Various chronic illnesses experienced by the children have been reported. Although these individuals may be at risk of immunological disorders and cancer, this Public Health Assessment cannot determine if the diseases experienced were caused by exposure to Baird and McGuire contaminants or some other exposure. Due to low statistical power, the determination of true cause and effect is unlikely to be proven in future investigations.

4. Small-size particulates generated during remediation will likely contain arsenic. Inhalation of arsenic has a synergistic effect on the development of lung cancer by cigarette smokers. If proper controls are not taken, inhalation of arsenic-containing particulates by smokers living or working nearby may result in an increased risk of lung cancer. Lung cancer incidence is already elevated for the census tract containing the Baird and McGuire site and for the towns of Holbrook and Randolph. Remediation is a short duration event. Engineering controls will be implemented to reduce particulate emission and a conservative maximum stack emission level has been established. Thus, the risk of developing lung cancer by this means will be reduced.

5. If proper controls are not taken, the possible adverse health effects from exposure to site contaminants during remediation would be the same as for past exposures. In particular, individuals in the immediate vicinity of the site with erythrocyte deficiencies, such as, glucose-6-phosphate dehydrogenase and pyruvate kinase deficiencies, could develop hemolytic anemia following naphthalene and methylarsine/arsine exposure. No information is available regarding the possible release of methylarsines and arsine from wetland soils or river sediment during excavation.

6. Individuals who eat fish caught from the Cochato River and associated water bodies (Sylvan Lake and Ice Pond) are probably exposed to Baird and McGuire contaminants. Because the extent the fishery is utilized and fish monitoring data are limited, no determination can be made regarding health impact.

7. Contaminant transport within the bedrock aquifer has not been thoroughly investigated; however, to characterize and remediate the bedrock aquifer would be difficult or impossible to accomplish. Information regarding the

location of private bedrock water supply wells is incomplete. It is possible, but not highly likely, that a bedrock well may capture contaminated water from the bedrock aquifer in the future. No private residential water supply wells are located in the pathway of the site's overburden ground water contaminant plume.

8. Although the planned site remediation should be protective of public health, remediation is not expected to remove all the contamination found in the site's soils, wetlands and aquifer and the Cochato River sediments. The additional discharge of contaminants from the site to the Cochato River may occur following remediation. Future exposures could occur dependent on changes in land use at the site, if the aquifer is used as a potable water source, and if dredging of the Cochato River occurs. Insufficient information is available to determine the potential for health impact, although continued Cochato River sediment monitoring is planned following sediment excavation.

Recommendations

1. The feasibility and usefulness of characterizing the South Street wellfield (aquifer test or further modeling) and municipal water distribution system should be determined in order to define the historical impact of the site on the water quality of the wellfield and to identify the residences that received South Street well water in the past. The MDPH is currently involved with discussion with technical consultants to determine the feasibility of this recommendation.

2. Careful ambient air monitoring during remediation is advised in order to prevent or mitigate the potential for any adverse health effect. In particular, during destruction of soil contamination, monitoring of small-sized particulate emission and careful control of emissions are strongly advised in order to minimize the possible multiplicative effect of inhalation of arsenic-containing particulates on cigarette smoking in the development of lung cancer.

3. Remediation workers should be notified of the concerns about erythrocyte enzyme deficiencies, such as, erythrocyte glucose-6-phosphate dehydrogenase and pyruvate kinase deficiencies, because individuals with these deficiencies could be susceptible to hemolytic anemia from exposure to naphthalene, methylarsines, and arsine. To minimize the possibility of developing hemolytic anemia, particular care is needed to provide the appropriate Personal Protective Equipment to any individual with this deficiency. The MDPH has informed the EPA contractors of this recommendation.

4. The population that utilizes the fishery should be determined in order to identify the existence of a subpopulation at greater risk of exposure and to assess the need for a fish advisory. If a subpopulation is identified, additional monitoring should be performed to determine the extent of contamination in fish (chlordane, DDT, DDE, DDD, dieldrin, polycyclic aromatic hydrocarbons, 2,3,7,8-TCDD, and, perhaps, arsenic speciation) in areas where fishing is most likely to occur (Sylvan Lake and Ice Pond). In conjunction with State and Local agencies, the MDPH is currently assessing the need for a fish advisory.

5. The presence of private bedrock potable water supply wells within a half mile of the site should be determined and, if present, periodic monitoring might be warranted.

6. Because remediation is not expected to result in complete clean-up of the site's soils, wetlands, and ground water, future land use restrictions should be considered to limit the use of the site, wetlands, and aquifer.

7. Prior to future dredging of the Cochato River for purposes such as flood control, monitoring of contaminants in sediments is advised (especially in the portion of the river near the site where clean fill will be placed and in the length of the river downstream to the Richardi Reservoir). A determination should be made as to whether or not proper sediment handling and disposal techniques are warranted in order to protect the worker and general population from adverse health effects.

8. The Baird and McGuire site, Holbrook, Massachusetts, has been evaluated by ATSDR's Health Activities Recommendation Panel for appropriate follow up with respect to health activities. This site is being considered for follow-up health activities. Specifically, the panel recommended:

   ATSDR and MDPH continue surveillance of cancer incidence and mortality, adverse pregnancy outcomes, and other adverse reproductive outcomes.

   Modelling of the distribution of water from the South Street wells to the residents of Holbrook and Randolph, prior to their closure in 1982, be performed to characterize the past exposure.

   A physician education and/or environmental health awareness program be performed to advise the medical community of the possible consequences of exposure to Baird and McGuire contaminants. In particular, immunodeficiency may increase the risk of developing non-Hodgkin's lymphoma and other diseases, especially

in persons with other chronic disorders or immune dysfunction. Physicians should be instructed on the need to take a complete and accurate exposure history. In addition, physicians should be informed of the pathways of exposure to site contaminants; e.g., the patient played or worked at the site, drank water from the South Street Wellfield, ingested fish from the Cochato River or associated water bodies downstream from the site, and, in the future, lived or worked near the site during incineration of contaminants and may have been exposed to fly ash. Such instruction will enable physicians to determine whether a patient is in a higher risk population (e.g., long-term residents of CT 4211 in Holbrook and CT 4203 in Randolph). This activity will be conducted by MDPH; ATSDR's Division of Health Education will provide resource information such as the Case Studies in Environmental Medicine: Arsenic Toxicity and the Public Health Statement from the Arsenic Toxicological Profile.

A community health education program should be developed to discourage cigarette smoking and to minimize the potential of a multiplicative interaction between cigarette smoking and the ingestion of arsenic-tainted fly ash in the development of lung cancer. This activity will be conducted by MDPH. ATSDR's Division of Health Education will provide resource information such as the Public Health Statement from the Arsenic Toxicological Profile.

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Certification

This Health Assessment was prepared by the Massachusetts Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health assessment was initiated.

Gregory V. Ulirsch

Technical Project Officer, SPS, RPB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Assessment and concurs with its findings.

Director, DHAC

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Appendices

A. Site Maps

B. Chemicals Used, Purchased, and/or Stored by the Baird & McGuire Chemical Company, Inc.

C. Baird and McGuire Site Chemical Contamination Tables

D. Current Descriptive Health Study Tables and Maps

APPENDIX A

Site Maps

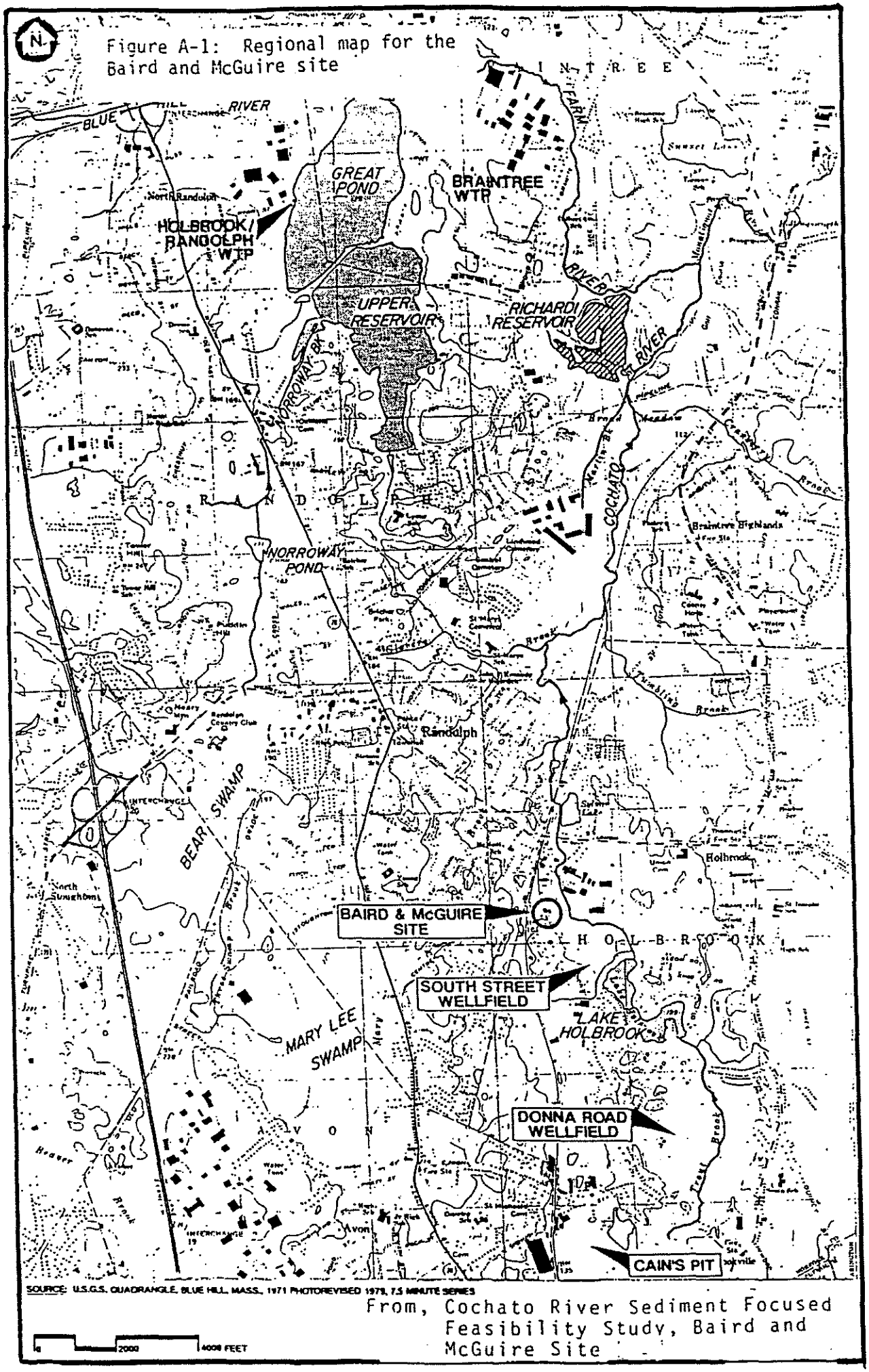
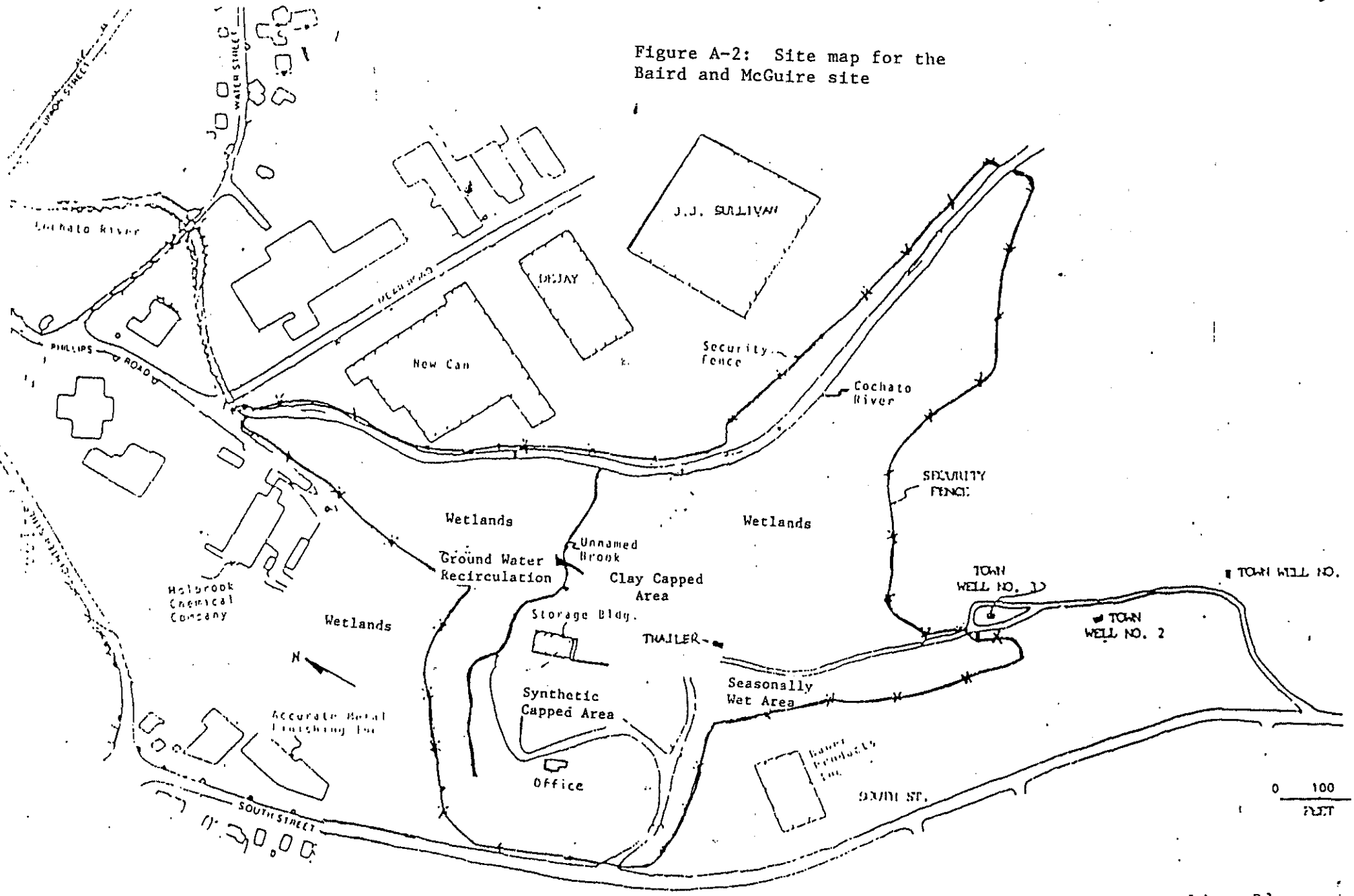


Figure A-1: Regional map for the Baird and McGuire site

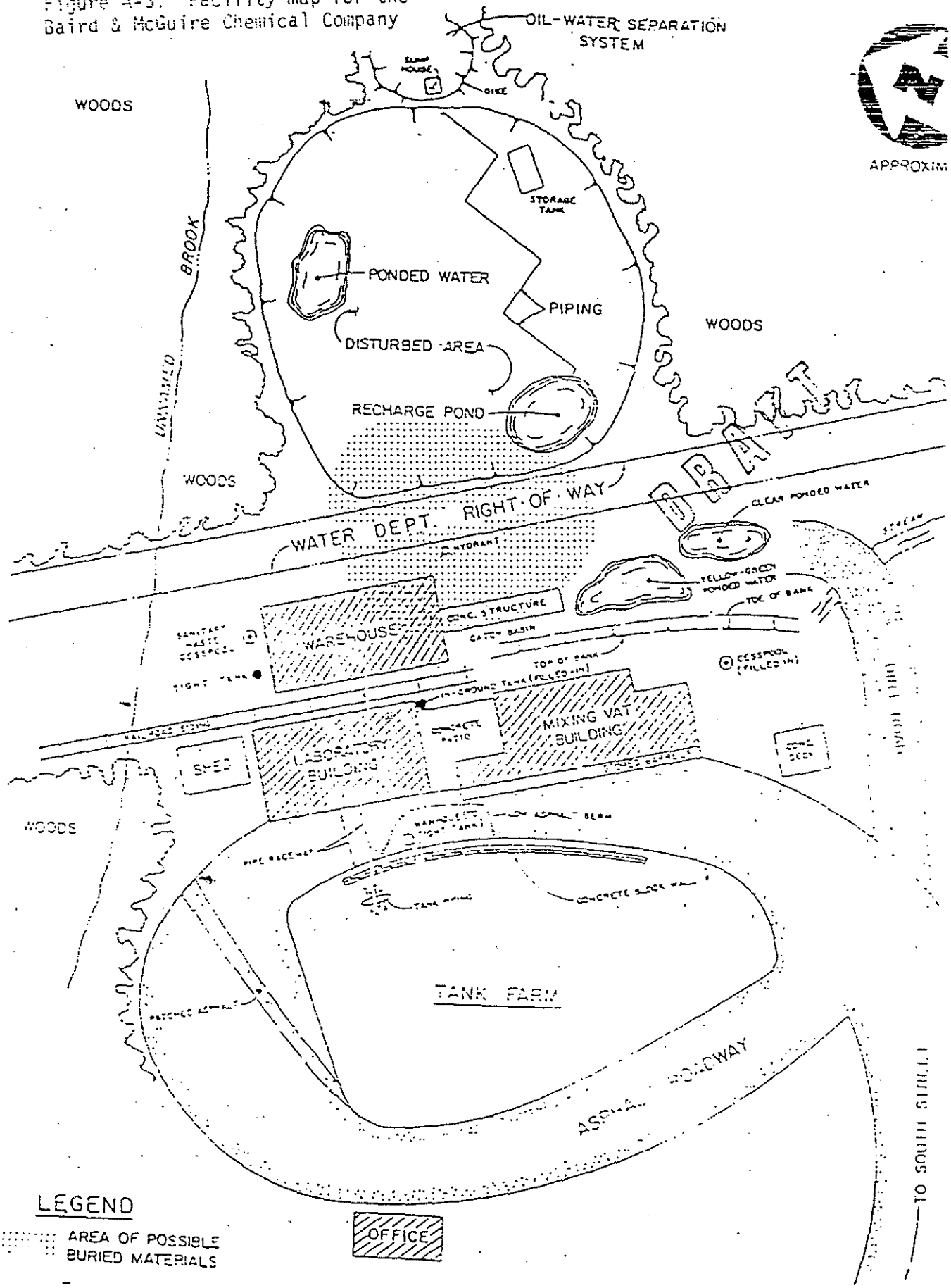
From, Cochato River Sediment Focused Feasibility Study, Baird and McGuire Site

Figure A-2: Site map for the Baird and McGuire site



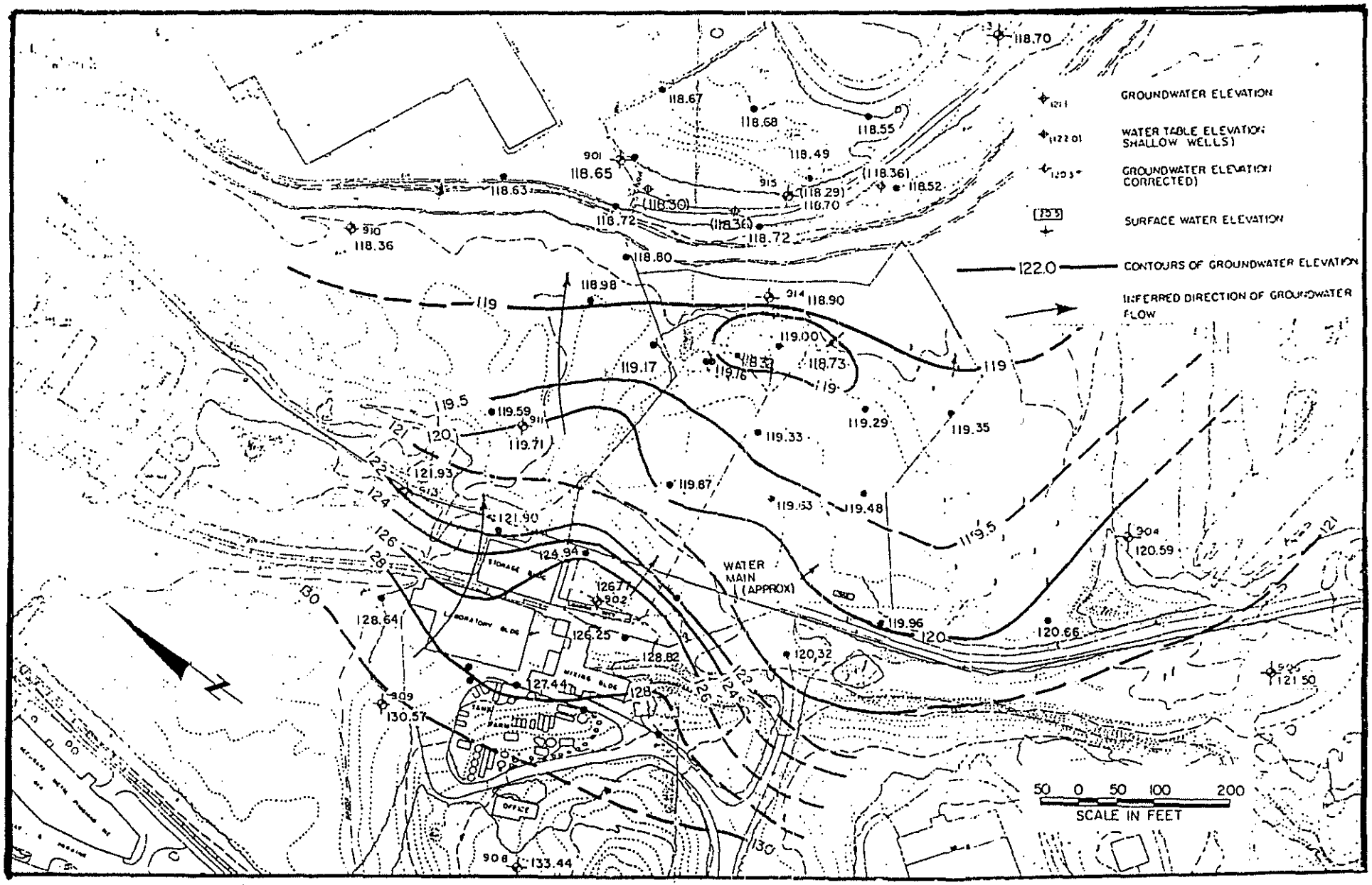
From, EPA/ERT Dioxin Sampling Plan
July, 1985

Figure A-3: Facility map for the Baird & McGuire Chemical Company



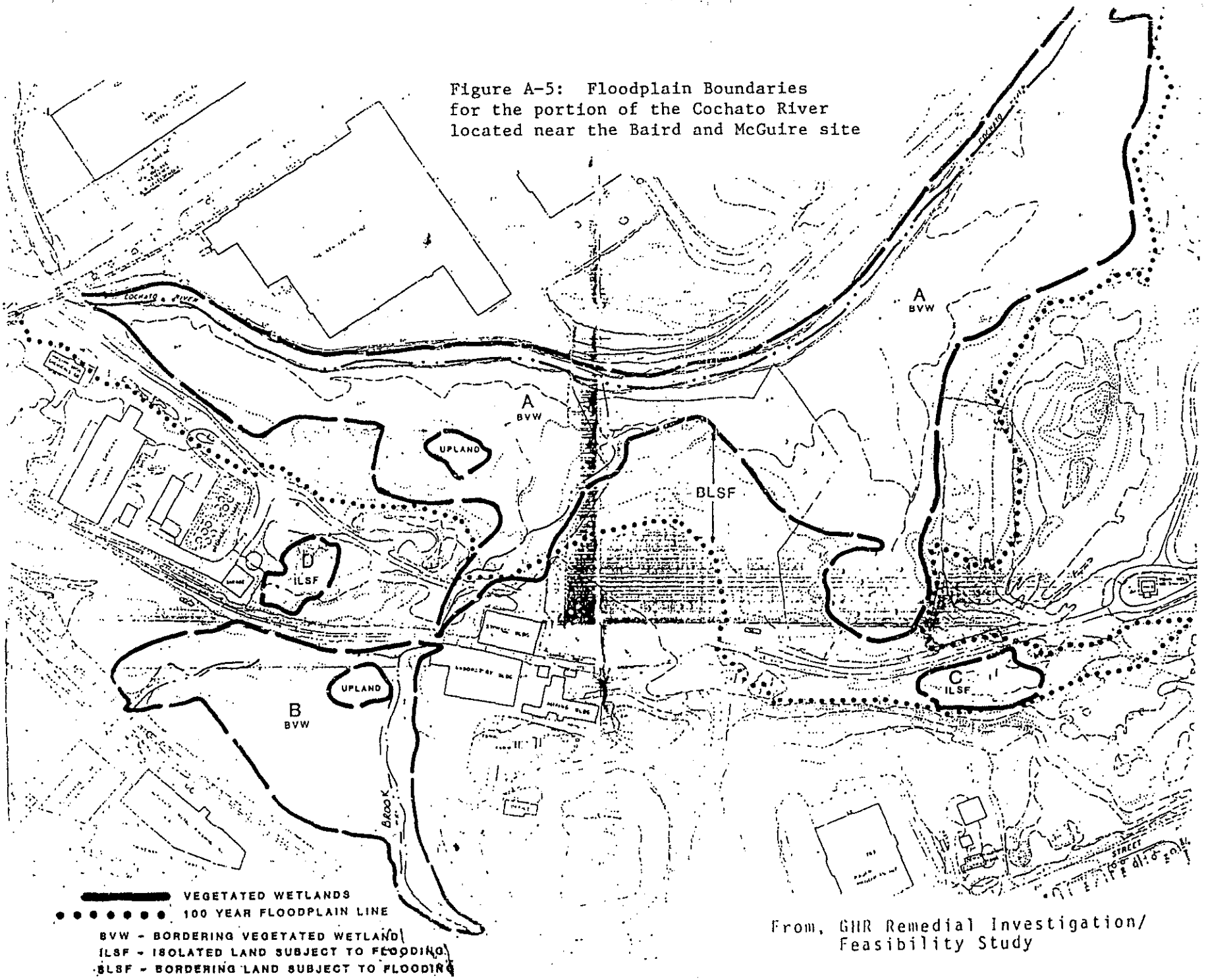
From, RI/FS Work Plan, NUS Corporation
March 1984

Figure A-4: Groundwater Contours
for the Baird and McGuire site



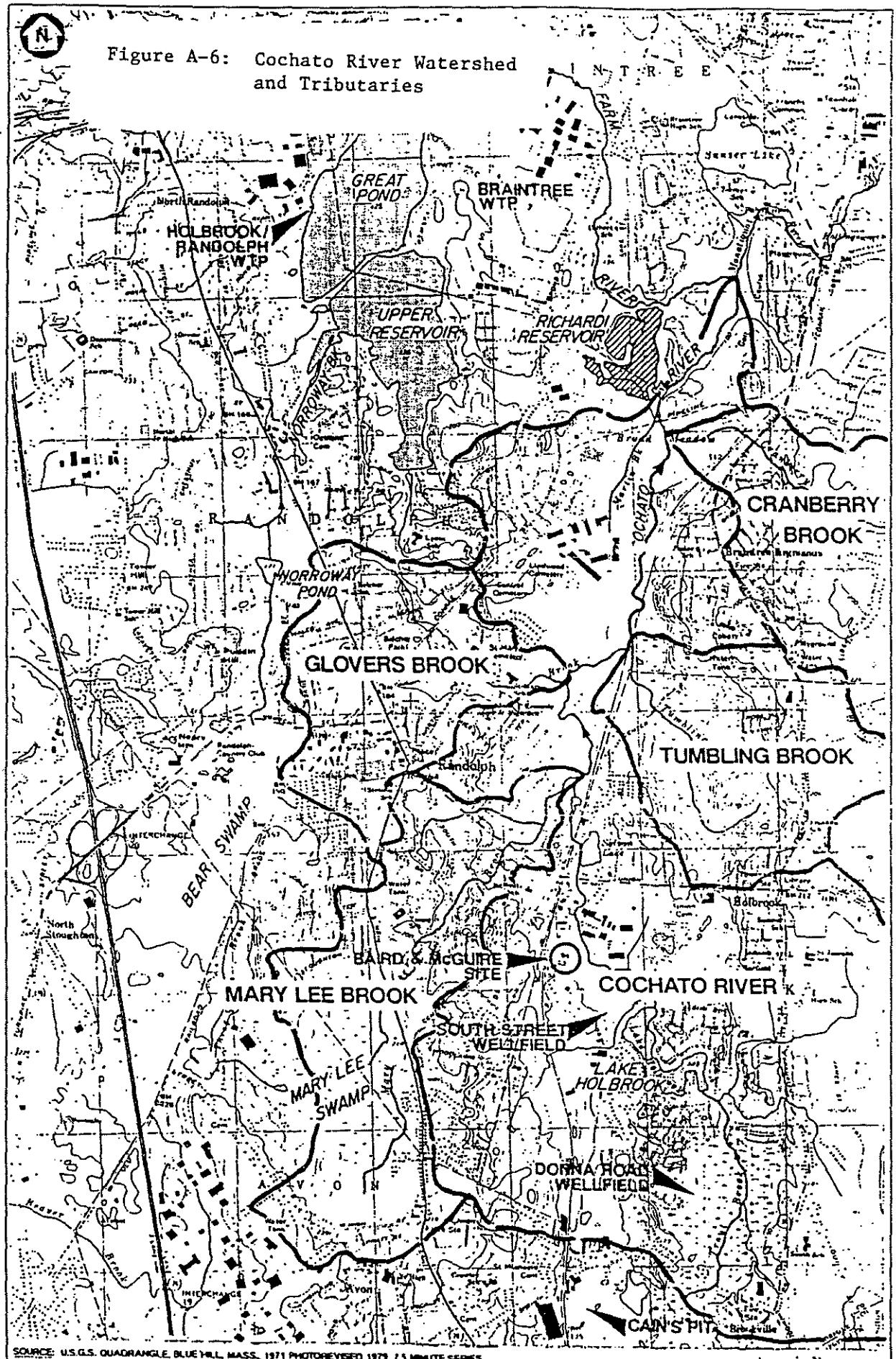
From, GHR Remedial Investigation/
Feasibility Study

Figure A-5: Floodplain Boundaries for the portion of the Cochato River located near the Baird and McGuire site



From, GHR Remedial Investigation/ Feasibility Study

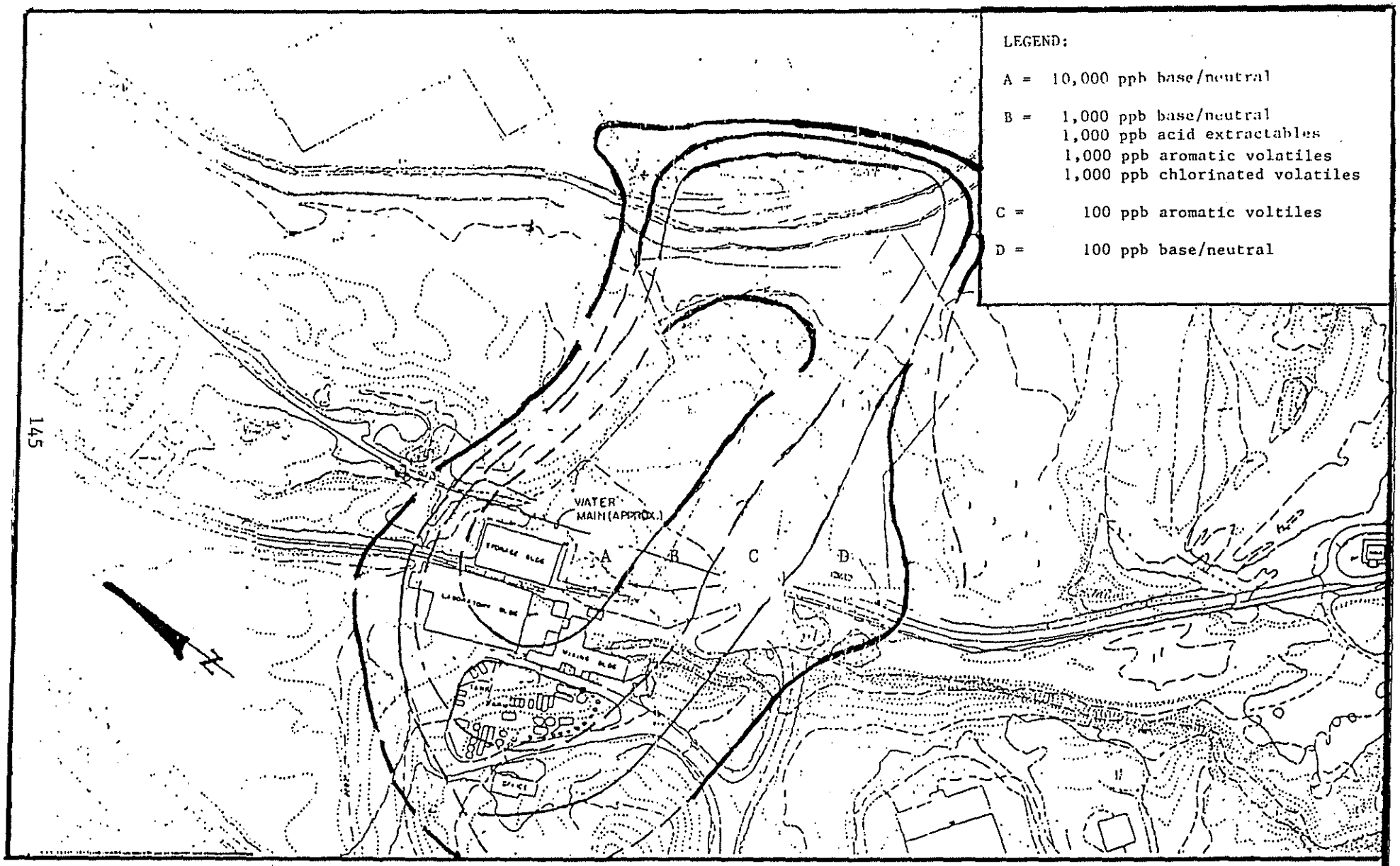
Figure A-6: Cochato River Watershed and Tributaries



SOURCE: U.S.G.S. QUADRANGLE, BLUE HILL, MASS., 1971 PHOTOREVISED 1979, 7.5 MINUTE SERIES

From, Cochato River Sediment Focused Feasibility Study, Baird and McGuire Site

Figure A-7: Groundwater Contamination
in the area of the Baird and McGuire site



From GHR Remedial Investigation/
Feasibility Study

APPENDIX B

Chemicals Used, Purchased, and/or Stored by the Baird & McGuire Chemical Company, Inc.

The Baird & McGuire Chemical Company, Inc. was involved in the manufacturing, mixing, batching and distribution of various types of chemical compounds such as herbicides, fungicides, insecticides, wood preservatives, soaps, floor waxes, and disinfectants. The following is a list of chemical compounds known to have been used, purchased, and/or stored by the company. The references utilized are listed at the end of the table.

TABLE B

Chemical compounds known to have been used, purchased, and/or stored by the Baird & McGuire Chemical Company, Inc.

benzene	benzene hexachloride
chlorinated solvents	toluene
xylene	methanol
carnauba waxes	coal tar
fuel oil #2	kerosene
mineral oil	mineral spirits
paraffin wax	tall oil
tar acid oil	wax polymers
cresols	dinitro-sec butyl phenol
naptha-aromatic	phenols
baygon 1.5 dipel	chlordane
DDT	diazinon
dieldrin	dinitrophenol
dinitro-sec butyl phenol	dinosel
lindane	malathion
methoxychlor	pyrethrum
sevin 41B, XLR, 2R, MDL	potassium hydroxide
ammonia compounds	ammonia compounds-quaternary
caustic potash	caustic soda
coconut fatty acids	coconut oil
detergents-synthetic	sodium hydroxide
pine oil	piperonyl butoxide
santophen 1 75%	isopropanol
silica-flaked	oil-neutral
sodium meta silicate	sodium tripolyphosphate
trisodium phosphate	hydroxyacetic acid
diol 40	flit
T.E.A.	acintol
triton N-101	han oil
creosote	koppers oil
140 solvent	16% floor wax
1291 polymer	K-MH 1.5
floor finish	thanite
lethane	dinitro 5-B
sodium arsenite	piperonyl butoxide

isopropylamine salt of dodecyl-benzene sulfonic acid
2-isopropyl-4-methyl-6-pyrimidinylphosphorothiol
20% xylene + 80% naptha-hi flash
2,4,5-trichlorophenoxy acetic acid

References:

* NUS Corporation. Preliminary Site Assessment, April 21, 1983. [85].

* NUS Corporation. Remedial Action Master Plan, May, 1983. [86].

* GHR Engineering Associates, Inc. Remedial Investigation Report, May 22, 1985. [43].

* Massachusetts Department of Labor & Industries. Baird & McGuire Main Files. [77].

  - Memorandum from Mr. Fahy and Dr. Maloof to Mr. Skinner, July 22, 1949.

  - Memorandum from Mr. Fahy to Dr. Elkins, July 14, 1954.

  - Memorandum from Mr. Pagnotto to Dr. Elkins, January 19, 1967.

  - Letter from Dr. Hervey B. Elkins, Division of Labor & Industries to Mr. Gordon Baird, Chairman of the Board, Baird and McGuire, Inc., January 24, 1967.

* Inventory from Baird & McGuire, Inc. to Fire Chief William Marble, Holbrook Fire Department, Holbrook, MA 02343, July 30, 1982.

APPENDIX C

Baird and McGuire Site

Chemical Contamination Tables

TABLE C-1A
Baird and McGuire Site
Holbrook, MA
On-site contamination[14, 15]

Compounds	Surface Soils[1] (ppm)[2]			Deep Soils (ppm)[2]			Ground Water[12] (ppb)[3]		
	freq.[5]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Facility area[13]:									
benzene	3/56	0.125	0.051	0/70	---	---	7/19	290	150
tetrachloroethylene	24/56	62	5.8	13/70	11	2.1	1/19	14	14
trichloroethylene	8/56	4.8	0.62	1/70	0.77	0.77	2/19	54	31
vinyl chloride	0/56	---	---	0/70	---	---	4/19	160	105
ethylbenzene	17/56	30	6.0	23/70	160	21	8/19	1100	503
xylenes (total)	24/56	300	48	32/70	750	78	7/19	4700	1986
2,4-dimethylphenol	2/56	2.2	1.3	3/70	0.79	0.52	10/19	2400	808
benzo(a)pyrene	6/56	9	2.9	1/70	1.9	1.9	0/19	---	---
fluoranthene	33/56	34	7.1	14/70	23	4.1	0/19	---	---
PAHs[6] (other)	44/56	12860	679	48/70	5590	579	11/19	10900	4369
2,3,7,8-TCDD[7]	12/35	0.0113	0.0024	0/0			0/0		
4,4'-DDT[8]	45/60	2900	204	30/70	268	18	5/19	0.4	0.2
4,4'-DDE[9]	39/60	420	37	28/70	1142	42	2/19	0.1	0.1
4,4'-DDD[10]	44/60	1300	114	56/70	280	24	6/19	1.1	0.5
dieldrin	32/60	52	8.8	38/70	26	3.7	4/19	1.8	0.6
chlordane	43/60	138000	3507	37/70	1200	63	4/19	0.5	0.5
alpha-BHC[11]	10/56	9.0	3.7	3/70	1.9	0.65	2/19	0.8	0.5
gamma-BHC	19/56	31	7.6	24/70	16	2.1	3/19	0.5	0.3
2,4-D[16]	4/28	17	4.1	12/41	7.1	2.2	3/3	18	8.5
2,4,5-T[17]	4/28	13	2.7	14/41	9.0	1.9	3/3	18	13
arsenic	36/37	380000	15944	50/70	1800	103	12/19	3850	1435

(cont.)

TABLE C-1A (cont.)
Baird and McGuire Site
Holbrook, MA
On-site contamination[14, 15]

Compounds	Sediments (ppb)[2]			Ambient Air (ug/m^3)[4]		
	freq.[5]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Facility area[13]:						
benzene	0/2	---	---	0/6	---	---
tetrachloroethylene	0/2	---	---	0/6	---	---
trichloroethylene	0/2	---	---	0/6	---	---
vinyl chloride	0/2	---	---	0/6	---	---
ethylbenzene	0/2	---	---	0/6	---	---
xylenes (total)	0/2	---	---	0/6	---	---
2,4-dimethylphenol	0/2	---	---	0/6	---	---
benzo(a)pyrene	0/2	---	---	0/6	---	---
fluoranthene	0/2	---	---	0/6	---	---
PAHs[6] (other)	2/2	96210	52329	1/6	0.11	0.11
2,3,7,8-TCDD[7]	0/2	---	---	0/1	---	---
4,4'-DDT[8]	0/2	---	---	0/6	---	---
4,4'-DDE[9]	1/2	1.6	1.6	0/6	---	---
4,4'-DDD[10]	0/2	---	---	0/6	---	---
dieldrin	0/2	---	---	0/6	---	---
chlordane	0/2	---	---	0/6	---	---
alpha-BHC[11]	0/2	---	---	0/6	---	---
gamma-BHC	0/2	---	---	0/0		
2,4-D[16]	1/1	0.27	0.27	0/0		
2,4,5-T[17]	1/1	0.08	0.08	0/0		
arsenic	2/2	2500	2050	0/6	---	---

Footnotes for Table C1-A:

1. sampling depth to three feet
2. ppm, parts per million or mg/kg, milligrams per kilogram
   ppb, parts per billion or ug/kg, micrograms per kilogram
3. ppb or ug/l, micrograms per liter
4. detection limits ranged from 0.003 to 0.08 micrograms per cubic meter, except for 2,3,7,8-TCDD which had a detection limit of 0.0022 parts per trillion or thousand (unclear)
5. freq., frequency, is the number above detection limit over the number of samples monitored
   max. conc., maximum concentration
   ave. conc., average concentration
6. polycyclic aromatic hydrocarbons - other: [2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene]
7. 2,3,7,8-TCDD; 2,3,7,8-tetrachlorodibenzo-p-dioxin
8. 4,4'-DDT; 4,4'-dichlorodiphenyltrichloroethane
9. 4,4'-DDE; 4,4'-dichlorodiphenyltrichloroethylene
10. 4,4'-DDD; 4,4'-dichlorodiphenyldichloroethane
11. BHC; benzene hexachloride
12. data obtained while ground water recirculation system was operating
13. facility area is the area formerly occupied by the tank farm and plant buildings now covered with a temporary synthetic cap and the creosote lagoon and surrounding areas now covered with a temporary clay cap
14. there are no surface water nor fish monitoring data for this area
15. References: [8,27,42,43]
16. 2,4-D; 2,4-dichlorophenoxyacetic acid
17. 2,4,5-T; 2,4,5-trichlorophenoxyacetic acid

TABLE C-1B
Baird and McGuire Site
Holbrook, MA
On-site contamination[14]

Compounds	Surface Soils[1] (ppm)[2]			Deep Soils (ppm)[2]			Ground Water[12] (ppb)[3]			Surface Water (ppb)[3]		
	freq.[5]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Non-facility area[13]:												
benzene	0/55	---	---	0/90	---	---	15/66	180	38	0/5	---	---
tetrachloroethylene	1/55	0.005	0.005	0/90	---	---	3/66	61	25	0/5	---	---
trichloroethylene	1/55	0.010	0.010	0/90	---	---	15/66	85	4.0	0/5	---	---
vinyl chloride	0/55	---	---	0/90	---	---	9/57	130	40	0/5	---	---
ethylbenzene	2/55	0.019	0.012	2/90	3.9	2.5	11/66	890	180	1/5	38	38
xylenes (total)	2/55	0.033	0.023	2/90	38	24	10/66	2800	407	1/5	790	790
2,4-dimethylphenol	3/55	2.1	1.4	1/90	0.078	0.078	7/66	2100	214	0/2	---	---
benzo(a)pyrene	9/55	18	3.0	1/90	1.1	1.1	1/66	27	27	0/2	---	---
fluoranthene	22/55	6000	286	2/90	1.6	1.5	1/66	172	172	0/2	---	---
PAHs[6] (other)	25/55	12800	521	10/90	13	2.4	15/66	15700	2561	1/2	40	40
2,3,7,8-TCDD[7]	25/72	0.048	0.0056	0/0			0/0			0/0		
4,4'-DDT[8]	63/94	630	40	41/90	22	1.5	12/66	10	1.3	0/2	---	---
4,4'-DDE[9]	57/94	47	4.6	33/90	1.6	0.16	10/66	9.8	1.4	0/2	---	---
4,4'-DDD[10]	70/94	1100	47	52/90	28	1.1	18/66	120	11	0/2	---	---
dieldrin	48/94	32	3.2	20/90	1.6	0.11	10/66	2.4	1.1	0/2	---	---
chlordane	54/94	1700	125	39/90	49	2.0	14/66	48	7.5	0/2	---	---
alpha-BHC[11]	0/55	---	---	0/90	---	---	6/66	1.8	0.42	0/2	---	---
gamma-BHC	3/55	0.013	0.007	2/90	0.11	0.006	10/66	4.2	0.57	0/2	---	---
2,4-D[15]	0/25	---	---	2/53	0.17	0.13	2/19	0.44	0.38	0/0		
2,4,5-T[16]	1/25	0.34	0.34	0/53	---	---	3/19	8.2	2.9	0/0		
arsenic	51/54	5700	218	52/90	155	14	15/66	3700	892	2/7	87	49

(cont.)

TABLE C-1B (cont.)
Baird and McGuire Site
Holbrook, MA
On-site contamination[14]

Compounds	Sediments (ppb)[2]			Fish (ppm)[2]			Ambient Air (ug/m^3)[4]		
	freq.[5]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Non-facility area[13]:									
benzene	2/46	58	54	0/0			0/1	---	---
tetrachloroethylene	1/46	21	21	0/0			0/1	---	---
trichloroethylene	0/46	---	---	0/0			0/1	---	---
vinyl chloride	0/46	---	---	0/0			0/1	---	---
ethylbenzene	10/46	3700	523	0/0			0/1	---	---
xylenes (total)	14/46	13000	1155	0/0			0/1	---	---
2,4-dimethylphenol	1/46	1080	1080	0/6	---	---	0/1	---	---
benzo(a)pyrene	5/46	3300	1318	0/6	---	---	0/1	---	---
fluoranthene	5/46	55000	11966	0/6	---	---	0/1	---	---
PAHs[6] (other)[7]	21/46	235600	22679	4/6	7.1	3.1	0/1	---	---
2,3,7,8-TCDD	0/22	---	---	0/0			0/3	---	---
4,4'-DDT[8]	13/46	183000	14493	1/6	0.37	0.37	0/1	---	---
4,4'-DDE[9]	11/46	56000	5950	6/6	1.0	0.53	0/1	---	---
4,4'-DDD[10]	21/46	190000	15413	6/6	4.7	2.1	0/1	---	---
dieldrin	5/46	12000	2459	0/6	---	---	0/1	---	---
chlordane	7/46	76000	18752	4/6	2.0	1.4	0/1	---	---
alpha-BHC[11]	0/46	---	---	0/6	---	---	0/1	---	---
gamma-BHC	4/46	175	70	0/6	---	---	0/1	---	---
2,4-D[15]	0/9	---	---	0/0			0/0		
2,4,5-T[16]	0/9	---	---	0/0			0/0		
arsenic	27/46	1290000	28948	0/0			0/1	---	---

Footnotes for Table C-1B:

1-3, 5-12. See footnotes for Table C-1A

4. Same as for Table C1-A, except for 2,3,7,8-TCDD which had a detection limit range of 0.0015 to 0.0028 parts per trillion or thousand (unclear)

13. Non-facility area encompasses that part of the site that was undeveloped, i.e., the northern and southern wetlands, the unnamed brook and areas adjacent to it, the seasonally wet area along the dirt access road leading to the South Street Wellfield, the Cochato River and the area east of the Cochato River

14. References: [8,22,27,42,43,46]

15. 2,4-D; 2,4-dichlorophenoxyacetic acid

16. 2,4,5-trichlorophenoxyacetic acid

Table C-2A
Baird and McGuire Site
Holbrook, MA
Off-site Contamination (Cochato River and Associated Water Bodies)[r, s]

Compounds	Upstream[a]			Downstream Tributaries[b]			Cochato River to Sylvan Lake[c]			Sylvan Lake[d]			Cochato River to Ice Pond[e]		
	freq.[j]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Sediments:															
TCE[k] (ppb)[l]	0/6	---	---	0/8	---	---	0/10	---	---	1/8	15	15	0/0		
vinyl chloride	0/6	---	---	0/8	---	---	0/10	---	---	1/8	22	22	0/0		
benzo(a)pyrene	0/6	---	---	1/8	1700	1700	3/10	4400	2790	1/8	330	330	0/0		
fluoranthene	2/6	580	365	6/8	5600	3343	8/10	9100	2555	3/8	2800	1510	0/0		
PAHs[m] (other)	3/6	1090	549	8/8	16520	6904	9/10	55720	11174	3/8	7400	3303	0/0		
2,3,7,8-TCDD[n]	0/1	---	---	0/0			0/1	---	---	0/1	---	---	0/0		
4,4'-DDT[o]	1/6	2500	2500	0/8	---	---	4/10	740	361	2/8	760	401	0/0		
4,4'-DDE[p]	1/6	23	23	0/8	---	---	0/10	---	---	2/8	380	275	0/0		
4,4'-DDD[q]	1/6	310	310	1/8	58	58	10/10	6000	1330	4/8	2000	597	0/0		
chlordane	1/6	300	300	0/8	---	---	5/10	2800	956	1/8	120	120	0/0		
arsenic (ppm)	0/6	---	---	3/8	6.4	4.0	9/10	27	14	3/8	54	21	0/0		
Surface Water:															
PAHs (other)	0/3	---	---	0/0			2/2	5	4	0/0			0/1	---	---
2,3,7,8-TCDD (ppb)	0/1	---	---	0/0			0/0			0/0			0/0		
arsenic (ppb)	1/2	16	16	10/41	29	7.1	5/9	24	10	0/0			0/1	---	---
Fish:															
PAHs (other) (ppm)	0/0			0/0			0/0			0/0			0/0		
2,3,7,8-TCDD (ppt)	1/1	1.0	1.0	0/0			0/0			1/1	3.0	3.0	1/1	4.5	4.5
4,4'-DDT (ppm)	0/0			0/0			0/0			0/0			0/0		
4,4'-DDE	0/0			0/0			0/0			0/0			0/0		
4,4'-DDD	0/0			0/0			0/0			0/0			0/0		

(cont.)

TABLE C-2A (cont.)
Baird and McGuire Site
Holbrook, MA
Off-site contamination (Cochato River and Associated Water Bodies)[r, s]

Compounds	Ice Pond[f]			Cochato River to Glovers Brook[g]			Cochato River to Richardi Reservoir[h]			Richardi Reservoir[i]		
	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
Sediments:												
TCE[k] (ppb)[l]	1/8	24	24	0/9	---	---	0/14	---	---	0/2	---	---
vinyl chloride	0/8	---	---	0/9	---	---	0/14	---	---	0/2	---	---
benzo(a)pyrene	2/8	2900	1650	2/7	340	225	2/14	3000	1845	0/2	---	---
fluoranthene	6/8	8800	2042	4/7	910	516	5/14	6300	1830	1/2	330	330
PAHs[m] (other)	6/8	18500	5100	4/7	2070	1544	7/14	38100	6447	2/2	660	495
2,3,7,8-TCDD[h]	0/0			0/2	---	---	0/1	---	---	0/1	---	---
4,4'-DDT[o]	2/8	170	145	2/9	1000	875	0/14	---	---	0/2	---	---
4,4'-DDE[p]	2/8	1000	860	6/9	580	302	0/14	---	---	0/2	---	---
4,4'-DDD[q]	7/8	5000	1929	6/9	1400	677	4/14	500	203	0/2	---	---
chlordane	3/8	4800	3210	3/9	570	485	0/14	---	---	0/2	---	---
arsenic (ppm)	8/8	334	117	6/9	81	30	12/14	40	12	1/2	6.6	6.6
Surface water:												
PAHs (other) (ppb)	0/0			0/0			0/3	---	---	0/0		
2,3,7,8-TCDD (ppb)	0/0			0/0			0/0			0/1	---	---
arsenic (ppb)	0/0			0/6	---	---	6/13	15	3.6	0/0		
Fish:												
PAHs (other) (ppm)	2/2	1.76	1.0	0/0			0/0			0/0		
2,3,7,8-TCDD (ppt)	0/0			0/0			0/0			0/0		
4,4'-DDT (ppm)	1/2	0.19	0.19	0/0			0/0			0/0		
4,4'-DDE	1/2	1.2	1.2	0/0			0/0			0/0		
4,4'-DDD	1/2	2.7	2.7	0/0			0/0			0/0		

Footnotes for Table C-2A:

a. The portion of the Cochato River and water bodies (Lake Holbrook and unnamed tributaries) draining into the Cochato River upstream of the site
b. Water bodies that drain into the Cochato River downstream of the site (Mary Lee Brook, Tumbling Brook, Glovers Brook, Martin Brook, and Cranberry Brook)
c. The portion of the Cochato River extending from the site to Sylvan Lake
d. Sylvan Lake - an overflow inlet separates the Cochato River from Sylvan Lake except at times of high water
e. The portion of the Cochato River extending from Sylvan Lake to Ice Pond
f. Ice Pond
g. The portion of the Cochato River extending from Ice Pond to Glovers Brook
h. The portion of the Cochato River extending from Glovers Brook to Richardi Reservoir
i. The Richardi Reservoir is separated from the Cochato River by a sluiceway which has been closed since 1983
j. freq., frequency detected - the number of positive detects over the number of samples monitored
max. conc., maximum concentration
ave. conc., average concentration
k. TCE, trichloroethylene
l. sediments: ppb, parts per billion or micrograms per kilogram (ug/kg)
ppm, parts per million or milligrams per kilogram (mg/kg)
surface water: ppb, parts per billion or micrograms per liter (ug/l)
fish: ppm, parts per million or mg/kg
ppt, parts per trillion or nanograms per kilogram (ng/kg)
m. PAHs (other); polycyclic aromatic hydrocarbons - other [2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene]
n. 2,3,7,8-TCDD; 2,3,7,8-tetrachlorodibenzo-p-dioxin
o. 4,4'-DDT; 4,4'-dichlorodiphenyltrichloroethane
p. 4,4'-DDE; 4,4'-dichlorodiphenyltrichloroethylene
q. 4,4'-DDD; 4,4'-dichlorodiphenyldichloroethane
r. if a compound of concern was not given for a particular media, then it was not detected or, on occasion, was not monitored
s. References: [8,22,27,42,43,46,62,73]

Table C-2B
Baird and McGuire Site
Holbrook, MA
Off-site Contamination[j,k]

Compounds	South Street Wellfield						North of Tank Farm					
	Surface Soils[i]			Subsurface Soils			Surface Soils			Subsurface Soils		
	freq.[a]	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
benzo(a)pyrene (ppb)[b]	0/8	---	---	0/20	---	---	1/3	370	370	0/5	---	---
fluoranthene	3/8	1200	810	0/20	---	---	2/3	590	570	0/5	---	---
PAHs (other)[c]	3/8	2850	1907	1/20	2860	2860	2/3	3460	2302	2/5	970	575
2,3,7,8-TCDD[d]	0/2	---	---	0/0			0/1	---	---	0/0		
4,4'-DDT[e]	6/8	700	130	7/19	480	33	3/3	350	138	3/5	130	77
4,4'-DDE[f]	2/8	23	23	4/19	430	127	3/3	110	63	2/5	13	9
4,4'-DDD[g]	5/8	850	186	9/19	2200	315	2/3	27	18	5/5	99	52
dieldrin	0/8	---	---	2/19	2.4	2.4	1/3	3.8	3.8	4/5	15	9.1
chlordane	1/8	12	12	7/19	1800	327	1/3	89	89	3/5	75	49
2,4-D[l]	0/8	---	---	1/19	250	250	0/3	---	---	0/5	---	---
2,4,5-T[m]	0/8	---	---	0/19	---	---	0/3	---	---	1/5	260	260
arsenic	0/8	---	---	2/20	52	30	0/3	---	---	1/5	7.9	7.9

	Cochato Industrial Park						South Street Wellfield					
	Overburden Ground Water			Bedrock Ground Water			Overburden Ground Water			Bedrock Ground Water		
	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.	freq.	max. conc.	ave. conc.
tetrachloroethylene (ppb)	2/5	8.3	6.7	0/1	---	---	0/6	---	---	0/0		
PAHs (other)	0/5	---	---	1/1	20	20	0/6	---	---	0/0		
4,4'-DDT (ppm)	0/5	---	---	0/1	---	---	1/6	0.032	0.032	0/0		
4,4'-DDE	0/5	---	---	0/1	---	---	1/6	0.017	0.017	0/0		
gamma-BHC[h]	0/5	---	---	0/1	---	---	1/6	0.15	0.15	0/0		
2,4-D	0/5	---	---	0/1	---	---	1/2	0.45	0.45	0/0		

Footnotes for Table C-2B:

a. freq., frequency detected - the number of positive detects over the number of samples monitored
   max. conc., maximum concentration
   ave. conc., average concentration
b. soils: ppb, parts per billion or micrograms per kilogram (ug/kg)
   ppm, parts per million or milligrams per kilogram (mg/kg)
   ground water: ppb, parts per billion or micrograms per liter (ug/l)
c. PAHs (other); polycyclic aromatic hydrocarbons (other): [2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene]
d. 2,3,7,8-TCDD; 2,3,7,8-tetrachlorodibenzo-p-dioxin
e. 4,4'-DDT; 4,4'-dichlorodiphenyltrichloroethane
f. 4,4'-DDE; 4,4'-dichlorodiphenyltrichloroethylene
g. 4,4'-DDD; 4,4'-dichlorodiphenyldichloroethane
h. gamma-BHC; gamma-benzene hexachloride (lindane)
i. surface soils were considered to be samples taken from a depth less than or equal to 2 feet from ground surface
j. if a compound of concern was not given for a particular media, then it was not detected or, on occassion, was not monitored
k. references: [8,27,42,43]
l. 2,4-D; 2,4-dichlorophenoxyacetic acid
m. 2,4,5-T; 2,4,5-trichlorophenoxyacetic acid

APPENDIX D

Current Descriptive Health Study

Tables and Maps

Table D-1
1982-1986 Cancer Incidence
Holbrook, MA

	Total			Male			Female		
Cancer Type	Obs	Exp	SIR	Obs	Exp	SIR	Obs	Exp	SIR
Stomach	2	4.7	42	2	3.0	67	0	1.8	--
Liver	0	0.9	--	0	0.6	--	0	0.3	--
Pancreas	5	4.2	118	2	2.1	95	3	2.1	140
Lung	44	29.5	149 ++	31	19.4	159 ++	13	10.4	124
Hemat./Retic	7	5.9	118	2	3.3	61	5	2.7	184
Bladder	8	8.3	96	8	6.2	129	0	2.2	--
Kidney	7	4.8	147	5	3.0	169	2	1.9	107
Lymphoma (NHL)	7	7.2	97	0	3.9	--	7	3.4	209 *
Hodgkins	1	2.1	48	1	1.1	87	0	0.9	--

Note: all figures rounded

Differences in totals for expected cases result from rounding to the nearest tenth

Obs = observed number of cases

Exp = expected number of cases

SIR = Standardized Incidence Ratio

+ = statistical significance at the $p<0.05$ level

++ = statistical significance at the $p<0.01$ level

* = borderline statistical significance ($p<0.06$)

Table D-2
1982-1986 Cancer Incidence
Randolph, MA

	Total			Male			Female		
Cancer Type	Obs	Exp	SIR	Obs	Exp	SIR	Obs	Exp	SIR
Stomach	18	15.3	118	11	9.3	118	7	6.0	116
Liver	3	2.9	102	2	1.9	102	1	1.0	100
Pancreas	16	13.7	117	5	6.5	76	11	7.2	153
Lung	112	92.0	122 +	66	59.7	111	46	32.7	141 +
Hemat./Retic	17	18.2	94	8	9.6	83	9	8.6	105
Bladder	35	26.7	131	26	19.5	133	9	7.4	122
Kidney	21	14.8	142	16	8.9	180 +	5	5.9	84
Lymphoma (NHL)	30	21.4	140 +	15	11.2	134	15	10.3	146
Hodgkins	5	5.5	91	1	3.0	33	4	2.5	159

*Note: all figures rounded
Differences in totals for expected values result from rounding to the nearest tenth

Obs = observed number of cases
Exp = expected number of cases
SIR = Standardized Incidence Ratio

+ = statistical significance at the $p<0.05$ level
++ = statistical significance at the $p<0.01$ level

Table D-3
1982-1986 Cancer Incidence
Holbrook, MA
CT 4211

	Total			Male			Female		
Cancer Type	Obs	Exp	SIR	Obs	Exp	SIR	Obs	Exp	SIR
Stomach	1	2.1	47	1	1.3	75	0	0.8	--
Liver	0	0.4	--	0	0.3	--	0	0.1	--
Pancreas	2	1.9	105	1	0.9	106	1	0.9	103
Lung	26	13.0	199 ++	19	8.6	220 ++	7	4.6	153
Hemat./Retic	4	2.7	150	2	1.5	138	2	1.2	163
Bladder	4	3.7	107	4	2.8	144	0	1.0	--
Kidney	6	2.1	283 +	4	1.3	306 +	2	0.8	241
Lymphoma (NHL)	5	3.2	156	0	1.7	--	5	1.5	333 +
Hodgkins	0	0.9	--	0	0.5	--	0	0.4	--
Soft tiss. sarcoma	1	0.7	148	0	0.4	--	1	0.3	344
Brain	2	1.7	120	1	0.8	126	1	0.9	113
Malig. Melanoma	2	2.1	96	2	0.9	203	0	1.1	--

Note: all figures rounded

Differences in totals for expected values result from rounding to the nearest tenth

Obs = observed number of cases

Exp = expected number of cases

SIR = Standardized Incidence Ratio

CT= census tract

+ = statistical significance at the $p<0.05$ level

++ = statistical significance at the $p<0.01$ level

Table D-4
1982-1986 Cancer Incidence
Randolph, MA
CT 4203

	Total			Male			Female		
Cancer Type	Obs	Exp	SIR	Obs	Exp	SIR	Obs	Exp	SIR
Stomach	7	7.3	95	3	4.3	69	4	2.9	134
Liver	1	1.4	72	1	0.9	110	0	0.5	--
Pancreas	7	6.6	106	1	3.1	33	6	3.5	170
Lung	51	43.1	118	29	27.5	106	22	15.5	142
Hemat./Retic	8	8.7	92	7	4.5	155	1	4.2	24
Bladder	18	12.8	141	16	9.2	174 +	2	3.6	56
Kidney	10	6.9	144	8	4.1	196 *	2	2.9	70
Lymphoma (NHL)	17	10.2	167 +	8	5.2	155	9	4.9	181 *
Hodgkins	1	2.6	39	1	1.4	72	0	1.2	--
Soft tiss. sarcoma	3	2.1	145	1	1.1	88	2	0.9	215
Brain	4	5.1	79	3	2.5	119	1	2.6	40
Malig. Melanoma	8	6.4	125	5	3.1	162	3	3.3	90

Note: all figures rounded

Differences in totals for expected values result from rounding to the nearest tenth

Obs = observed number of cases

Exp = expected number of cases

SIR = Standardized Incidence Ratio

CT = census tract

+ = statistical significance at the $p<0.05$ level

++ = statistical significance at the $p<0.01$ level

Table D-5
1982-1986 Non-Hodgkin's Lymphoma Incidence
Holbrook, MA

	Obs	Exp	SIR	95% Confidence Intervals lower limit	upper limit
Holbrook					
total	7	7.2	97	39	200
males	0	3.9	---	0	95
females	7	3.4	209 *	83	424
CT 4211					
total	5	3.2	156	51	365
males	0	1.7	---	0	217
females	5	1.5	333 +	108	778
CT 4212					
total	2	4.0	50	6	181
males	0	2.2	---	0	168
females	2	1.9	108	13	380

Note: all figures rounded

+ = statistical significance at the $p<0.05$ level .
++ = statistiacl significance at the $p<0.01$ level
* = borderline statistical significance ($p<0.06$)

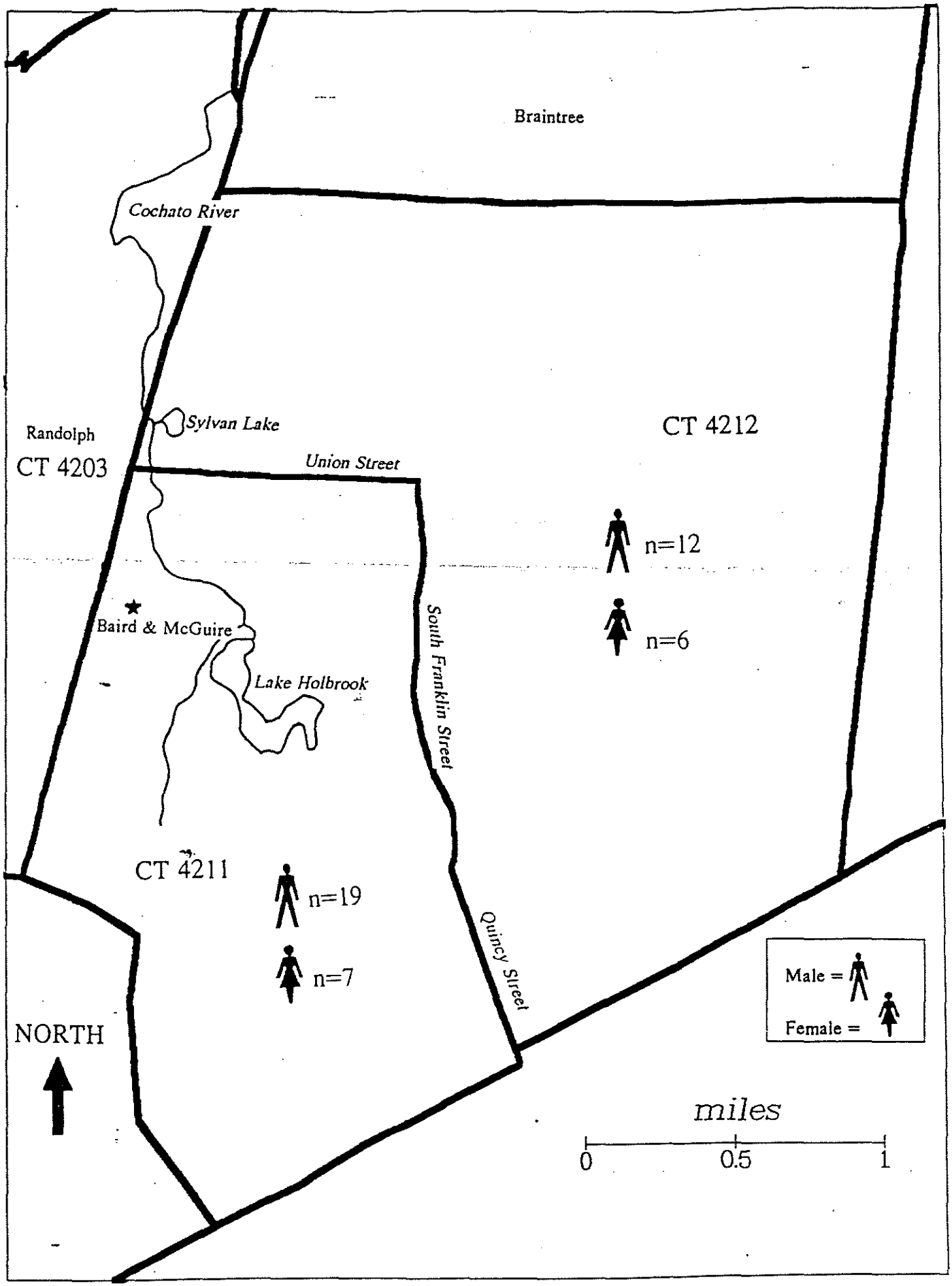
Table D-6
1982-1986 Non-Hodgkin's Lymphoma Incidence
Randolph, MA

	Obs	Exp	SIR	95% Confidence Intervals lower limit	upper limit
Randolph					
total	30	21.4	140 +	95	200
males	15	11.2	134	75	221
females	15	10.3	146	82	240
CT 4201					
total	4	6.1	66	18	168
males	1	3.1	33	0.8	180
females	3	2.9	101	21	302
CT 4202					
total	9	5.2	172	79	329
males	6	2.9	205	76	450
females	3	2.3	128	27	381
CT 4203					
total	17	10.2	167 +	97	267
males	8	5.2	155	66	303
females	9	4.9	181 *	84	349
CT 4211, 4203 combined					
total	22	13.4	165 +	103	249
males	8	6.9	116	50	228
females	14	6.5	216 ++	118	361

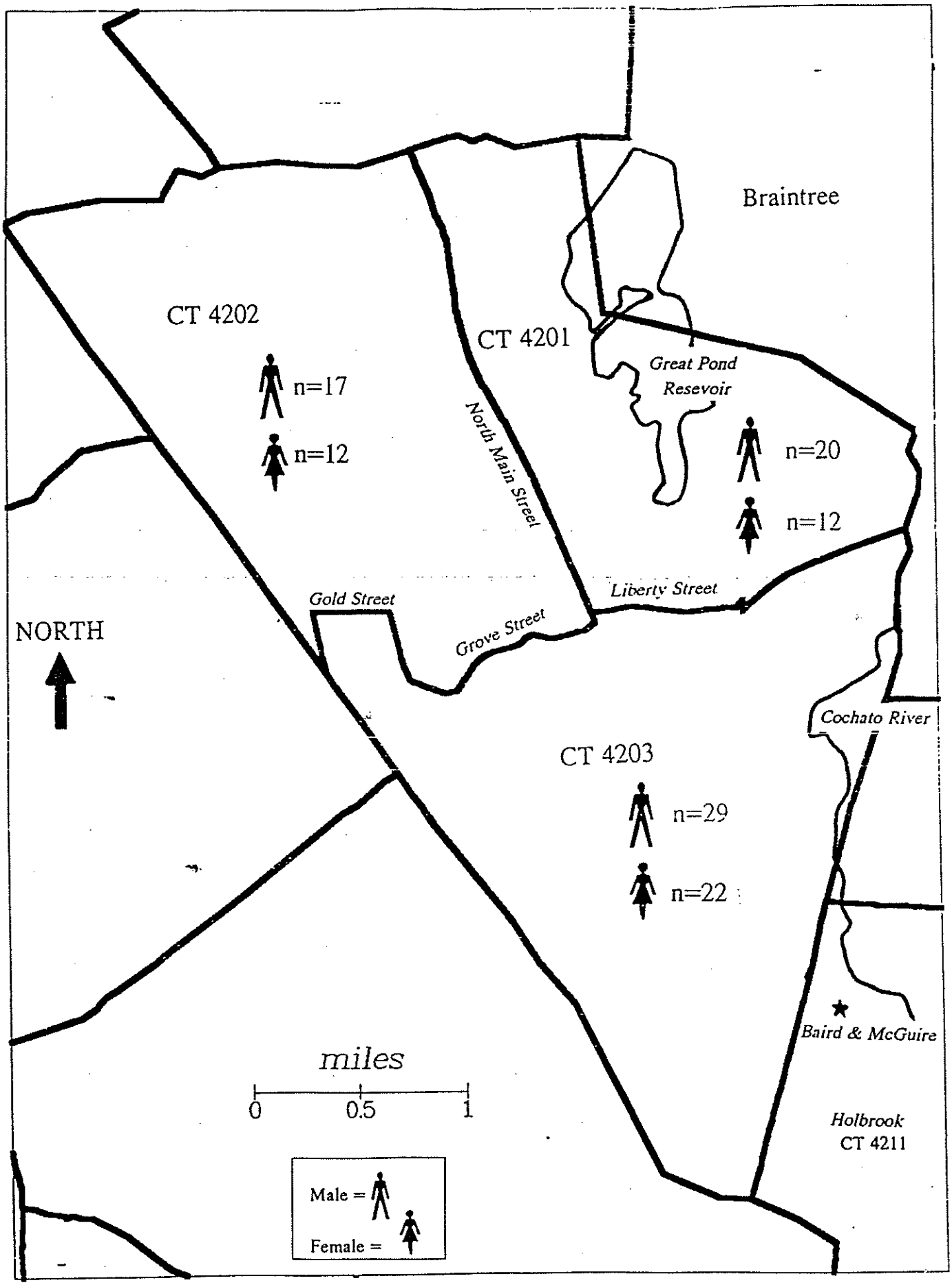
Note: all figures rounded

+ = statistical significance at the $p<0.05$ level
++ = statistical significance at the $p<0.01$ level
* = borderline statistical significance ($p<0.06$)

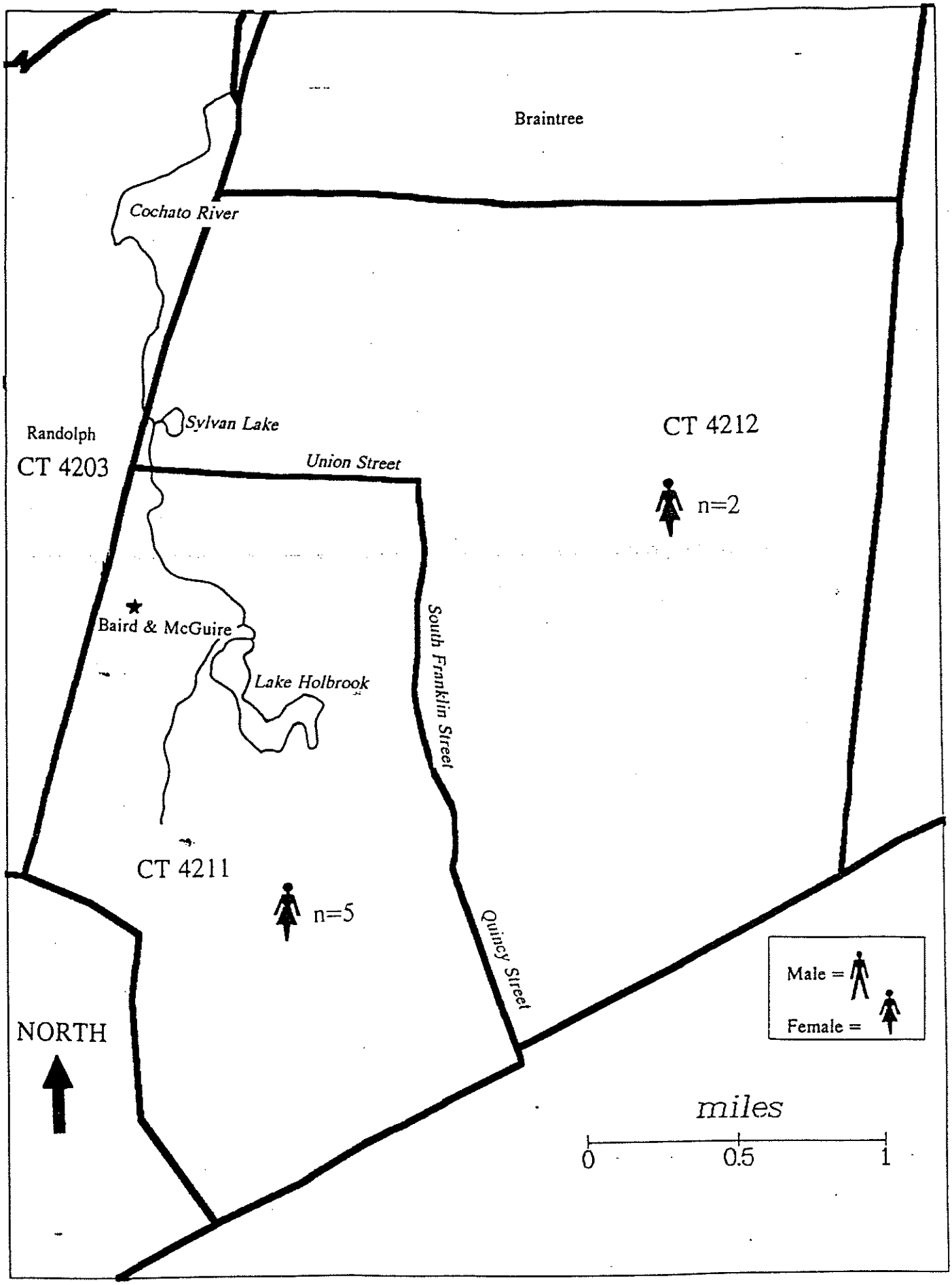
LUNG CANCER INCIDENCE IN HOLBROOK, MA 1982-1986



LUNG CANCER INCIDENCE IN RANDOLPH, MA 1982-1986

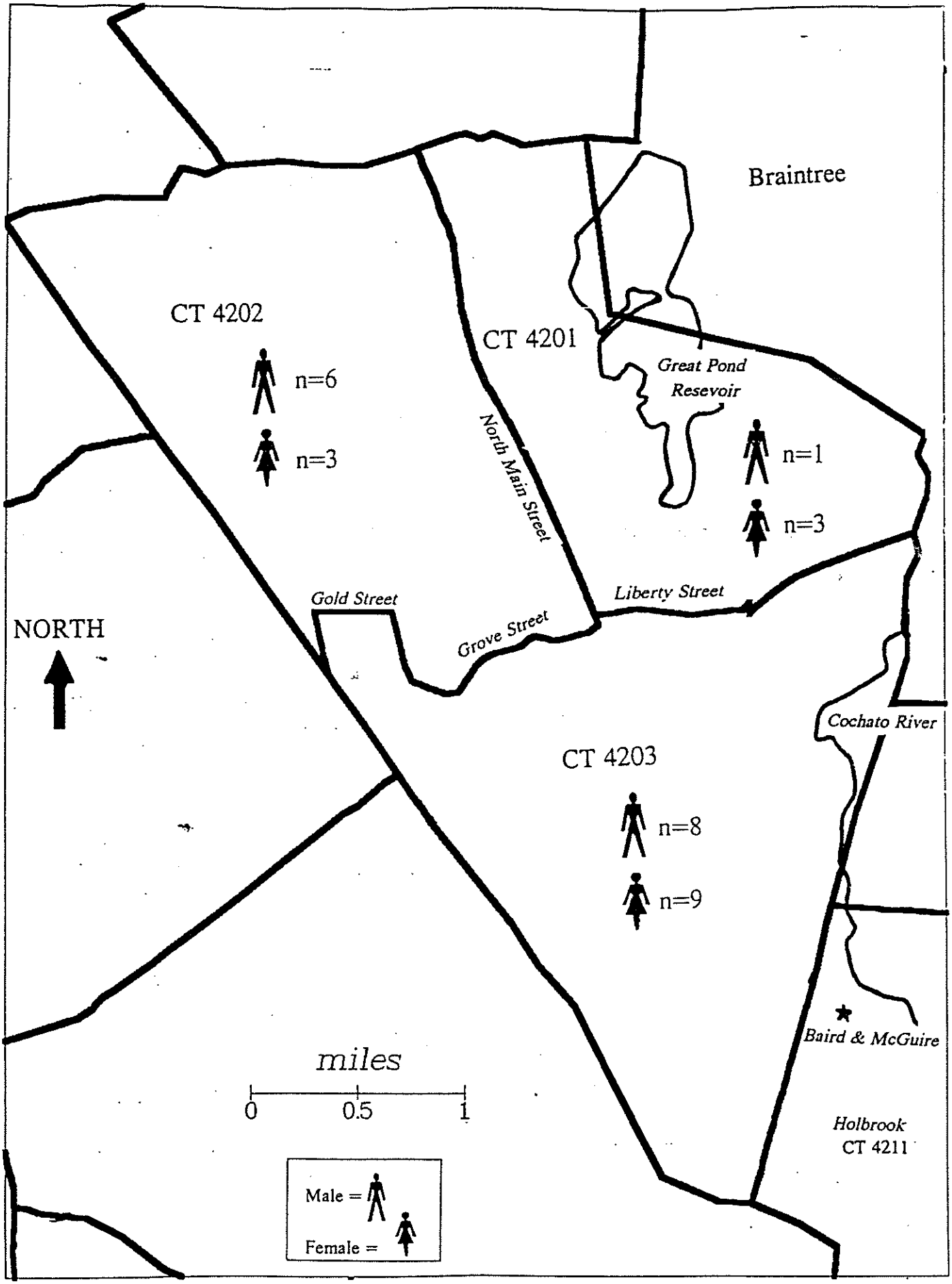


NON-HODGKIN'S LYMPHOMA INCIDENCE IN HOLBROOK, MA 1982-1986



MAP D-4

NON-HODGKIN'S LYMPHOMA INCIDENCE IN RANDOLPH, MA 1982-1986



APPENDIX E

Public Comment Period--Technical Correspondence

(Appendix E does not reflect the more than two hundred phone calls received regarding this document)

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
WRITTEN CORRESPONDENCE			
Center for Environmental Health Studies John Snow Research and Training Institute			X
Center for Risk Analysis Department of Health Policy and Management Harvard School of Public Health			X
Department of Environmental Protection One Winter Street Boston, MA			X
Holbrook Conservation Commission	X	X	
Holbrook Public Works Department		X	
Resident: Attleboro			X
Resident: Holbrook		X	X
Resident: Holbrook		X	X
Resident: Randolph		X	X
Resident: Randolph			X
Resident: Nashua,NH		X	X
Resident: Holbrook	X	X	
Former Resident of area	X		x
Resident: Stoughton			X
Attorney at Law Boston,MA		X	
Environmental Scientist Jason M. Cortell and Associates Inc. Waltham, MA		X	
Information Services Gradient Corporation		X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Cambridge, MA			
Ketchum Public Relations Washington, D.C.		X	
Attorney at Law Martin, Magnuson, McCarthy and Kenney Boston, MA		X	
The Barletta Co., Inc. Roslindale, MA		X	
Resident: Beaver Dam, WI		X	
Alceon Corporation Cambridge, MA		X	
Sheinfeld, Maley & Kay Houston, TX		X	
Williams and Cuker Philadelphia, PA		X	
TRC Environmental Consultants, Inc. East Hartford, CT		X	
Law Offices of Carney, Stephenson, Badley, Smith & Spellman, P.S. Seattle, Washington		X	
Regional Water Quality Manager Pennsylvania Department of Environmen Norristown, PA		X	
Yellow Freight System, Inc. Overland Park, Kansas		X	
Legislative Asst. McKenna and Cuneo Attorneys and Counselors Washington, D.C.		X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Information Request	Comments
PHONE INQUIRES			
New York Department Conservation Buffalo, N.Y.		X	
Physician Harvard School of Public Health Boston, MA		X	
Resident: Attleboro		X	
Health Agent Randolph Board of Health		X	
Resident: Braintree		X	
Resident: Quincy	X	X	
Resident: Randolph	X	X	
Holbrook Conservation Commission		X	
Martin, Magnuson, McCarthy, and Kenney Boston, MA		X	
Office of Standford Lewis Acton, MA		X	
Resident: Sharon (former resident Holbrook)	X	X	
Resident: Weymouth (former resident: Randolph)	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X	X	
Resident: Holbrook	X	X	
Town Hall, Holbrook		X	
Resident: Hull	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
(former resident: Holbrook)			
Resident: Brockton (former resident: Holbrook)	X	X	
EPA RPM	X	X	
Resident: Derry, N.H. (former resident: Randolph)	X	X	
Resident: Holbrook	X	X	
Resident: Holbrook		X	
Resident: Randolph	X	X	
Resident: N. Easton (former resident: Holbrook)	X		X
Barletta Engineering	X		X
Resident: Sharon (former resident: Randolph)	X	X	
Resident: Onset (former resident: Holbrook)	X	X	
Attorney at Law	X	X	
Resident: Randolph	X	X	
Resident: Dorchester	X	X	
Resident: East Lyme, C.T. (former resident: Holbrook)	X	X	
Resident. Holbrook	X	X	
Resident: Unknown	X	X	
Resident: Holbrook	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Resident: South Easton (mother former resident:Randolph)	X	X	
Resident: Randolph	X	X	
Resident: Quincy (Moving to area)		X	
Resident: East Bridgewater	X	X	
Resident: Unknown		X	
Resident: Unknown	X	X	
Resident: Randolph	X	X	
Resident: Needham (former resident: Holbrook)	X	X	
Resident: Unknown	X		X
Resident; Del Rey, FL (former resident: Randolph)	X		X
Resident: Unknown	X		
Resident: Randolph			X
Resident: Holbrook	X		X
Resident: Vinyard Haven	X		X
Resident: Holbrook		X	
Resident: Randolph		X	
Attorney at Law		X	
Physician		X	
Engineer US Army Corps of Engineers	X		

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
DPH Attorney			X
Resident: Holbrook			X
Industrial Hygienist		X	X
Resident: Brockton (former resident: Randolph)	X		X
Resident: Centerville	X		
Resdient: Randolph	X	X	
Ketchum Public Relations			X
Holbrook Board of Health			X
IES, consulting firm	X		
Resident: Randolph	X	X	
Resident: Warwick (former resident: Resident)	X	X	
Resident: Holbrook	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X		X
Resident: Randolph	X		X
Resident: Wintrop		X	
Physician Harvard Community Health Plan	X		
ATSDR Rep Region I	X		
Resident: Randolph	X		
Resident: Holbrook	X		

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Resident: Randolph	X		
Resident: Holbrook	X		
Resident: Holbrook	X		
Attorney at Law Hale and Dorr Boston, MA		X	
Resident: Holbrook			
Resident: Randolph	X		
Resident: Canton	X		
Resident: Gilford, N.H. (former resident: Holbrook)	X		
Resident: Holbrook	X		
Resident: Randolph	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X		
Resident: Norwood	X		X
Resident: Randolph	X		
Resident: Holbrook	X	X	
Resident: Holbrook	X	X	
Resident: Brockton (former resident: Randolph)	X	X	
Resident: Roslindale (former resident: Holbrook)	X	X	
Attorney at Law Dames and Moore	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Cambridge, MA			
Ketchum Public Relations Washington, D.C.		X	
Attorney at Law Martin, Magnuson, McCarthy and Kenney Boston, MA		X	
The Barletta Co., Inc. Roslindale, MA		X	
Resident: Beaver Dam, WI		X	
Alceon Corporation Cambridge, MA		X	
Sheinfeld, Maley & Kay Houston, TX		X	
Williams and Cuker Philadelphia, PA		X	
TRC Environmental Consultants, Inc. East Hartford, CT		X	
Law Offices of Carney, Stephenson, Badley, Smith & Spellman, P.S. Seattle, Washington		X	
Regional Water Quality Manager Pennsylvania Department of Environmen Norristown, PA		X	
Yellow Freight System, Inc. Overland Park, Kansas		X	
Legislative Asst. McKenna and Cuneo Attorneys and Counselors Washington, D.C.		X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Information Request	Comments
PHONE INQUIRES			
New York Department Conservation Buffalo, N.Y.		X	
Physician Harvard School of Public Health Boston, MA		X	
Resident: Attleboro		X	
Health Agent Randolph Board of Health		X	
Resident: Braintree		X	
Resident: Quincy	X	X	
Resident: Randolph	X	X	
Holbrook Conservation Commission		X	
Martin, Magnuson, McCarthy, and Kenney Boston, MA		X	
Office of Standford Lewis Acton, MA		X	
Resident: Sharon (former resident Holbrook)	X	X	
Resident: Weymouth (former resident: Randolph)	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X	X	
Resident: Holbrook	X	X	
Town Hall, Holbrook		X	
Resident: Hull	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
(former resident: Holbrook)			
Resident: Brockton (former resident: Holbrook)	X	X	
EPA RPM	X	X	
Resident: Derry, N.H. (former resident: Randolph)	X	X	
Resident: Holbrook	X	X	
Resident: Holbrook		X	
Resident: Randolph	X	X	
Resident: N. Easton (former resident: Holbrook)	X		X
Barletta Engineering	X		X
Resident: Sharon (former resident: Randolph)	X	X	
Resident: Onset (former resident: Holbrook)	X	X	
Attorney at Law	X	X	
Resident: Randolph	X	X	
Resident: Dorchester	X	X	
Resident: East Lyme, C.T. (former resident: Holbrook)	X	X	
Resident. Holbrook	X	X	
Resident: Unknown	X	X	
Resident: Holbrook	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Resident: South Easton (mother former resident:Randolph)	X	X	
Resident: Randolph	X	X	
Resident: Quincy (Moving to area)		X	
Resident: East Bridgewater	X	X	
Resident: Unknown		X	
Resident: Unknown	X	X	
Resident: Randolph	X	X	
Resident: Needham (former resident: Holbrook)	X	X	
Resident: Unknown	X		X
Resident; Del Rey, FL (former resident: Randolph)	X		X
Resident: Unknown	X		
Resident: Randolph			X
Resident: Holbrook	X		X
Resident: Vinyard Haven	X		X
Resident: Holbrook		X	
Resident: Randolph		X	
Attorney at Law		X	
Physician		X	
Engineer US Army Corps of Engineers	X		

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
DPH Attorney			X
Resident: Holbrook			X
Industrial Hygienist		X	X
Resident: Brockton (former resident: Randolph)	X		X
Resident: Centerville	X		
Resdient: Randolph	X	X	
Ketchum Public Relations			X
Holbrook Board of Health			X
IES, consulting firm	X		
Resident: Randolph	X	X	
Resident: Warwick (former resident: Resident)	X	X	
Resident: Holbrook	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X		X
Resident: Randolph	X		X
Resident: Wintrop		X	
Physician Harvard Community Health Plan	X		
ATSDR Rep Region I	X		
Resident: Randolph	X		
Resident: Holbrook	X		

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Resident: Randolph	X		
Resident: Holbrook	X		
Resident: Holbrook	X		
Attorney at Law Hale and Dorr Boston, MA		X	
Resident: Holbrook			
Resident: Randolph	X		
Resident: Canton	X		
Resident: Gilford, N.H. (former resident: Holbrook)	X		
Resident: Holbrook	X		
Resident: Randolph	X	X	
Resident: Randolph	X	X	
Resident: Randolph	X		
Resident: Norwood	X		X
Resident: Randolph	X		
Resident: Holbrook	X	X	
Resident: Holbrook	X	X	
Resident: Brockton (former resident: Randolph)	X	X	
Resident: Roslindale (former resident: Holbrook)	X	X	
Attorney at Law Dames and Moore	X	X	

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Bethesda, MD			
Resident: W. Bridgewater (former resident of Randolph)	X	X	
Cambridge Environmental		X	
Oncologist Brockton, MA		X	X
Anonymous call	X		
Resident: Holbrook	X	X	
Resident: Holbrook	X	X	
Resident: Warwick (former resident: Holbrook)	X	X	
Resident: Chelsea (former resident: Holbrook)	X	X	
Resident: Mapleton, UT (former resident: Holbrook)	X	X	
ENSR Corporation Information Center Acton, MA		X	
Oncologist Deaconess Hospital Boston, MA	X		X
Resident: Brockton (former resident: Holbrook)	X		
Environmental Scientist Jason M. Cortell and Associates, Inc.		X	
Site manager,DEP Bureau of Waste Site Cleanup Boston, MA	X		

BAIRD AND MCGUIRE
PUBLIC COMMENT

Name and Address	Information Supplied	Request	Comments
Attorney at Law Hale and Dorr Boston, MA		X	
Physician U. Mass. Medical Center Worcestor, MA	X		
Holbrook Selectmen's Office		X	
Site Manager,DEP DEP		X	
Real Estate Agent Mayers Real Estate	X		
Engineer	X		
Resident: Salem Salem, MA 01970			X